City of Tucson

Community Economic Security and Climate Action Analysis

Submitted to:

The City of Tucson
Office of Conservation and Sustainable Development

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westmoreland ASSOCIATES

A CLIMATE & ENERGY GROUP

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Westmoreland Associates is a Climate and Energy Group based in Tucson, Arizona. Lead authors of this report were: David Schaller, Principal Investigator, Christopher Juniper, Chief Energy Economist, and Jeremy Mohr, Chief Climate Scientist. The work contained herein represents a deliverable to the City of Tucson's Office of Conservation and Sustainable Development under Contract 100512.

Table of Contents

List of Figures

List of Appendices

Acknowledgements

We wish to thank the many individuals and organizations who provided data, references, resources, and most of all their time as we sought information necessary to the completion of this report. While we have worked to present the most accurate and professional analysis possible, no doubt errors have crept in and may have yet eluded our most careful edits. For those we take full responsibility and offer our sincerest apologies to the reader. We have pledged to correct in a timely manner those errors brought to our attention within the useful life span of this analysis.

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List of Acronyms

ACC	Arizona Corporation Commission
(C)AC	(Central) Air-Conditioning unit
ACCA	Air Conditioning Contractors of America
ACS	American Community Survey
ADEQ	Arizona Department of Environmental Quality
AEI	American Enterprise Institute
AFV	Alternative Fueled Vehicle
ARRA	American Recovery and Reinvestment Act
BAC	Bicycle Advisory Committee
Btu	British Thermal Unit
CACP	Clean Air and Climate Protection
CAFE	Corporate Average Fuel Economy
CAP	Climate Action Plan
Ccf	Centum cubic-feet
CDBG	Community Development Block Grant
CFL	Compact Fluorescent Lamp
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COT	City of Tucson
DOE	U.S. Department of Energy
ECO	Energy Conservation Ordinance
EEP	Electric Efficiency Program
EIA	U.S. Energy Information Agency
EPA	U.S. Environmental Protection Agency
EPC	Energy Performance Contracting
ESCO	Energy Service Company
EU	European Union
EV	Electric Vehicle
FHFA	Federal Housing Financing Agency
FIRST	Financing Initiative for Renewable and Solar Technology
FIT	Feed-In Tariff
FTE	Full-Time Equivalent
GBC	Green Business Certification
GEV	Grid-Enabled Vehicle
GHG	Greenhouse Gas
GPCD	Gallons Per Capita per Day
GREET	Greenhouse Gases, Regulated Emissions, and Energy use in Transportation model
HCFC	Hydrochlorofluorocarbon
HCT	High Capacity Transit
HOV	High-Occupancy Vehicle
HPS	High-Pressure Sodium (lamp)
HVAC	Heating, Ventilation, Air Conditioning
ICLEI	International Council for Local Environmental Initiatives
IEA	International Energy Agency
IECC	International Energy Conservation Code
IPCC	Intergovernmental Panel on Climate Change
IRC	International Residential Code
kWh	Kilowatt-Hour
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
LEV	Low-Emission Vehicle
LFG	Landfill Gas
LPS	Low-Pressure Sodium (lamp)
MCPA	Mayors' Climate Protection Agreement
MIT	Massachusetts Institute of Technology
MMBtu	Million Btus
MPG(e)	Miles Per Gallon (equivalent)
MW	Megawatt (1,000 kilowatts)
MWCOG	Metropolitan Washington Coalition of Governments
NGO	Non-Governmental Organization
NRC	National Research Council
NREL	National Renewable Energy Lab
O&M	Operation and Maintenance
OCSD	City of Tucson Office of Conservation and Sustainable Development
PACE	Property Assessed Clean Energy financing
PAG	Pima Association of Governments
PBI	Performance Based Incentive
PHEV	Plug-in Hybrid Electric Vehicle
PSI	Pounds per Square-Inch
PV	Photovoltaic
REC	Renewable Energy Credit
RECO	Residential Energy Conservation Ordinance
REST	Renewable Energy Standard Tariff
SAGCC	Southern Arizona Green Chamber of Commerce
SDHW	Solar Domestic Hot Water
SEER	Seasonal Energy Efficiency Ratio
SGESD	St. George Utah Energy Services Department
SOV	Single Occupancy Vehicle
SRCC	Solar Rating and Certification Corporation
SWG	Southwest Gas
TCC	Tucson Convention Center
tCO_2e	Metric Ton of Carbon Dioxide Equivalent
TDOT/ADOT/CDOT	Tucson/Arizona/City Department Of Transportation
TEP	Tucson Electric Power
TIA	Tucson International Airport
TIGER	Transportation Investments Generating Economic Recovery
TRP	Travel Reduction Program
TUL	Tucson Urban League
UA	University of Arizona
UES	Unisource Energy
UFI	Up-Front Incentive
UHI	Urban Heat Island effect
VMT	Vehicle Miles Traveled
WA	Westmoreland Associates
WAP	Weatherization Assistance Program
WMA	Warm-Mix Asphalt
ZEV	Zero- (tailpipe) Emission Vehicle
ZILCH	Zero Interest Loans for Conservation Help

Executive Summary

This report presents work performed by Westmoreland Associates under a Climate Change Planning contract awarded by the City of Tucson and managed by the City's Office of Conservation and Sustainable Development (OCSD). The work is a detailed analysis of a suite of climate change mitigation measures and includes projected greenhouse gas (GHG) reductions, energy savings, and costs/benefits of each. The overall goal was to identify the potential for these measures, if implemented, to contribute to the City's commitment under the U.S. Mayors' Climate Protection Agreement (MCPA). The MCPA goal calls for a reduction in greenhouse gases in the City of Tucson to a level 7% below 1990 levels by 2012.

At the outset, we noted that the City and community have independently made many important steps toward reducing the City's GHG emissions over the past few years, especially through the increasing use of energy efficiency and solar energy technologies. These include policies to mandate solar stub-outs, build more energy-efficient City buildings, encourage water conservation, promote transit, create a bike-friendly City, and update the City's Land Use Code in support of more transit-oriented and sustainable development. The City's designation as a Solar America City has made it a recognized leader in solar energy deployment on government buildings.

In addition, Tucson home and business owners continue to add solar energy systems to their buildings making them more energy efficient using a range of state, federal, and utility incentives. Rainwater harvesting technologies are also being adopted, helping reduce the energy costs of delivering potable water to end-users. Moreover, Tucsonans continue to advance the City's reputation as a national leader in bike-friendly communities.

With this as context, we took the assigned measures and generated likely savings and costs associated with them ranging from a voluntary corporate climate challenge program to enhanced energy efficiency programs in the residential and commercial sectors to incentivized programs for increased use of solar and clean vehicle technology. The original matrix of assigned measures can be found in **Appendix A**. Through our analysis contained herein, some measures were combined for the sake of clarity and brevity. The original measure designations have been maintained throughout the report for consistency.

What began as an analysis of the energy, cost and GHG reduction potential of 54 different possible supporting policies and action by the City quickly demonstrated a wealth of additional co-benefits from those policies: economic, public health, and community security. We have highlighted these co-benefits in our analysis of each measure.

Some exciting examples of co-benefits to particular GHG reduction measures include:

- The increased use of intersection roundabouts not only saves electricity used in signalization and avoids fuel wasted by vehicles idling also results in significant reductions in roadway accidents, injuries and fatalities, medical costs, and City emergency response costs, while offering cost-neutrality in the case of most new construction.

- The replacement of conventional residential streetlights with light emitting-diode (LED) fixtures (already underway in the City) shows quick economic payback. Furthermore, LED lamps are long-lived and allow for the increased productivity of City staff who would no longer need to make frequent lamp exchanges at over 8,000 City-maintained streetlights.

- Residential energy efficiency upgrades save homeowners money but also result in more comfortable homes as desert temperatures increase. Money saved stays in the community longer, enhances household purchasing power, and increases home value and resale potential.

- An anti-idling measure not only saves thousands of gallons of gasoline and diesel fuel daily but would also improve local air quality, reduce noise, enhance vehicle engine life, and improve overall community well-being.

FINDINGS

Given the present timing of this report and the City's schedule for bringing it forward for Mayor and Council consideration, most if not all of the measures being evaluated herein would likely not see implementation until sometime in 2012. Therefore, we believe it is not realistic to expect any measurable contribution from them towards the City's 2012 MCPA goal. Our analysis of those measures, which might begin accruing GHG reduction benefits by the end of 2012 if implemented immediately, show that they would only contribute 9% to the City's 2012 reduction goal (See **Figure 1**).

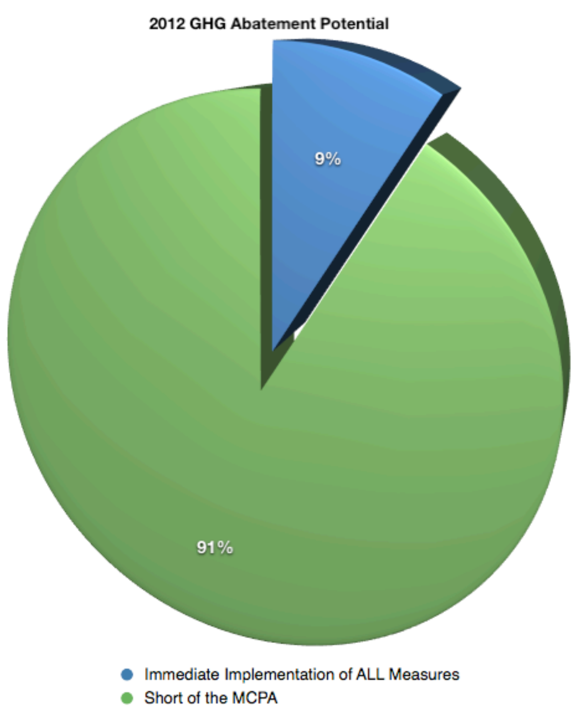

Figure 1

Nevertheless, we wanted to illustrate the mid- to long-term potential of the measures evaluated. To make this possible given the absence of any GHG reduction goal for the City beyond 2012, we have extended the "7% below 1990 levels" goal forward to 2020. This required generating a projected business-as-usual GHG emissions level for the City of Tucson. Thus, we project 7.34 million metric tons of carbon dioxide-equivalent (CO_2e) for 2020 against which to evaluate the reduction potential of each individual measure. (See **Appendix F**)

Figure 2 shows City of Tucson GHG emissions under three scenarios: 1) historical emissions from 1990-2008 using PAG Inventory data [purple]; 2) a business-as-usual emissions trajectory from 2008 through 2020 [blue], and 3) the emissions trajectory needed to achieve the proposed GHG reduction target by 2020, beginning essentially immediately [green]. For a variety of considerations, we did not want to presume full implementation of all analyzed measures in 2020 and therefore did not develop a curve showing the emissions reduction potential of that scenario. However, the reader is able to take the potential ~50% reduction value we developed for the measures (see below) and imagine a curve essentially splitting the difference between the business-as-usual curve [blue] and the target curve [green] showing reductions needed to meet the 2020 target.

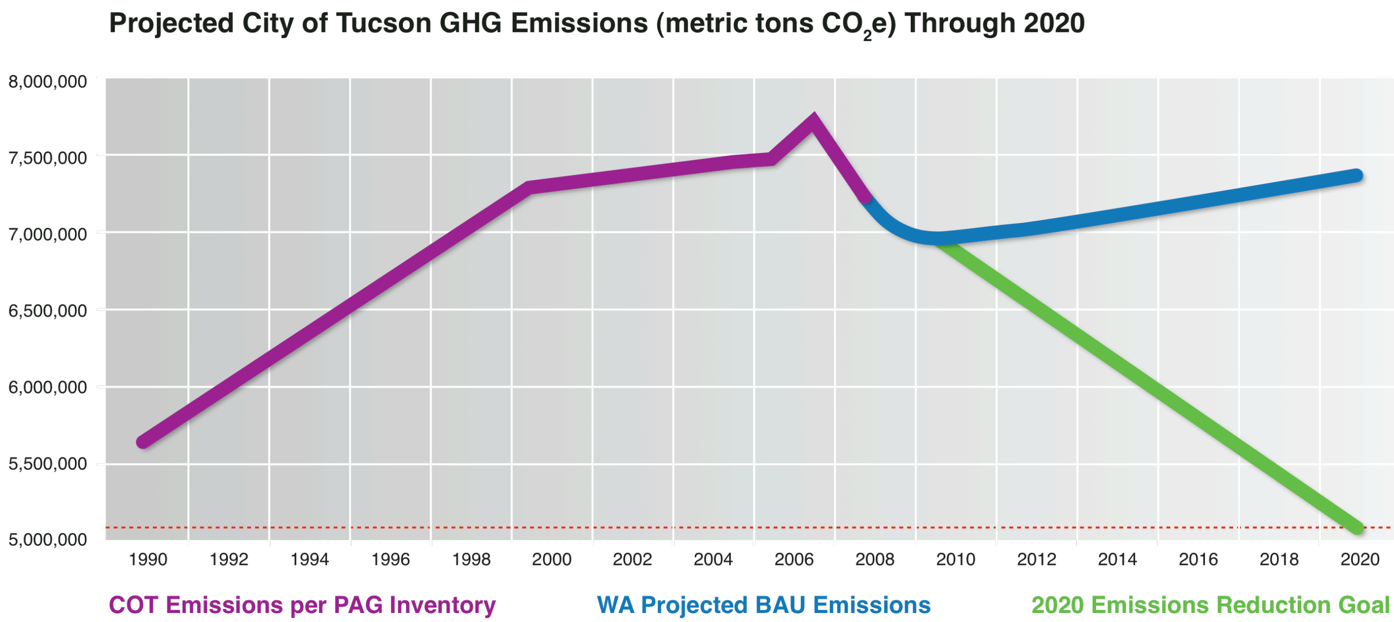

Figure 2

As a result of our analysis, we determined that, if implemented, the measures analyzed would collectively contribute 50.2% of this 2020 GHG reduction goal. The representative contribution of each measure to the 2020 goal is highlighted in **Figure 3**.

From an economic vantage, among the most promising of the measures evaluated were:

1) Transit-oriented Development
2) Improved Vehicle Maintenance
3) Anti-Idling Ordinance
4) Enhanced Direct Load Control in Commercial
5) Time-of-Sale Residential Retrofits
6) Mandatory Cool Roofs

We found that all measures evaluated delivered net economic savings over the design life of the technology or activity. This is the case even for those measures offering lower GHG reduction potential than others and should suggest that there are economic reasons for considering these measures even outside the significance of their contribution to a climate mitigation strategy.

2020 GHG Abatement Potential

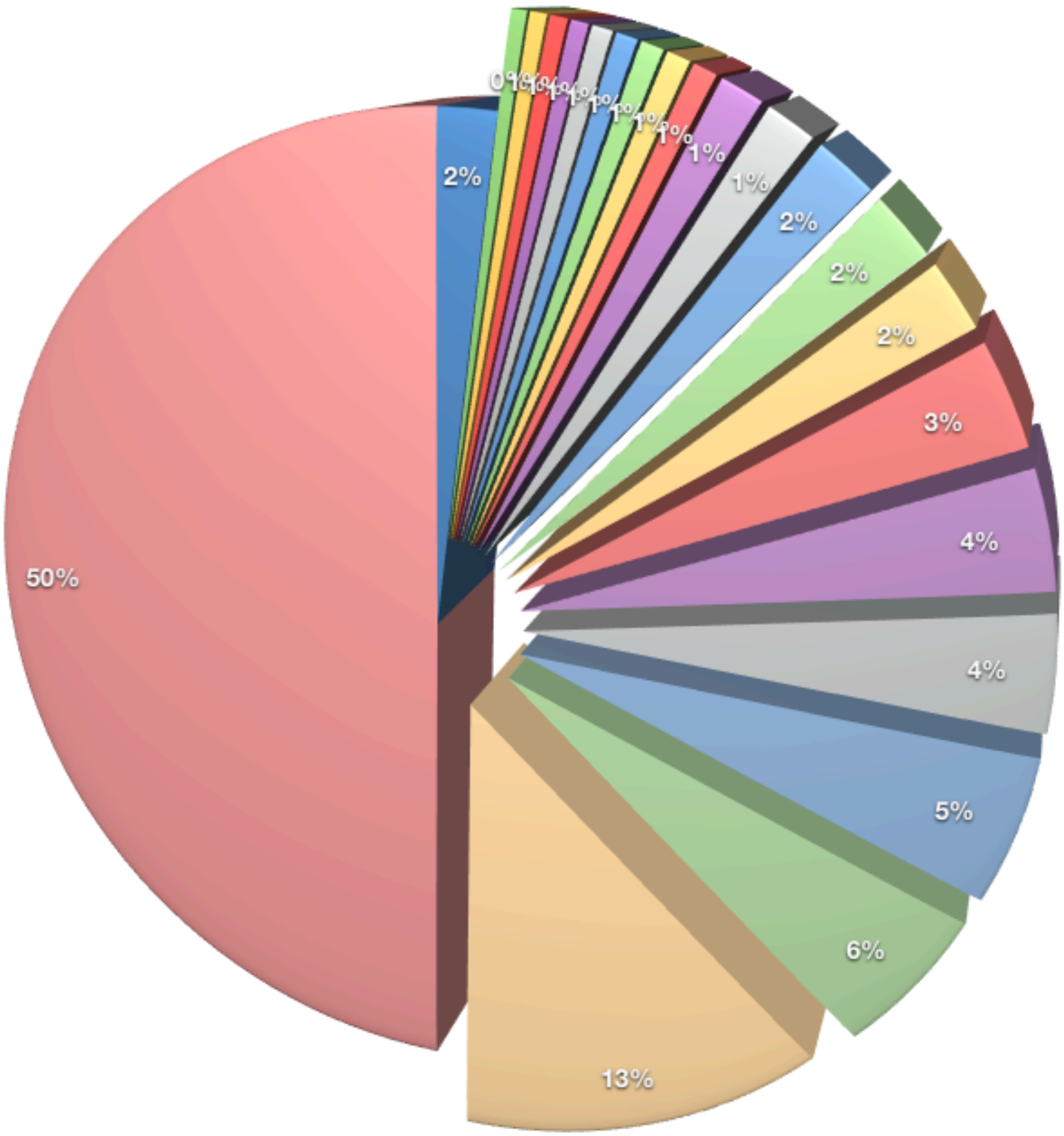

Figure 3

We note that many of the measures analyzed will stimulate GHG savings well beyond 2020, over the lifetime of the implementation technologies. On the basis of cost-per-ton (savings) the relative contribution of individual measures in 2020 is shown in the Marginal Abatement Cost Curve (MAC Curve) in **Figure 4**.

Marginal Abatement Cost Curve for Select Measures

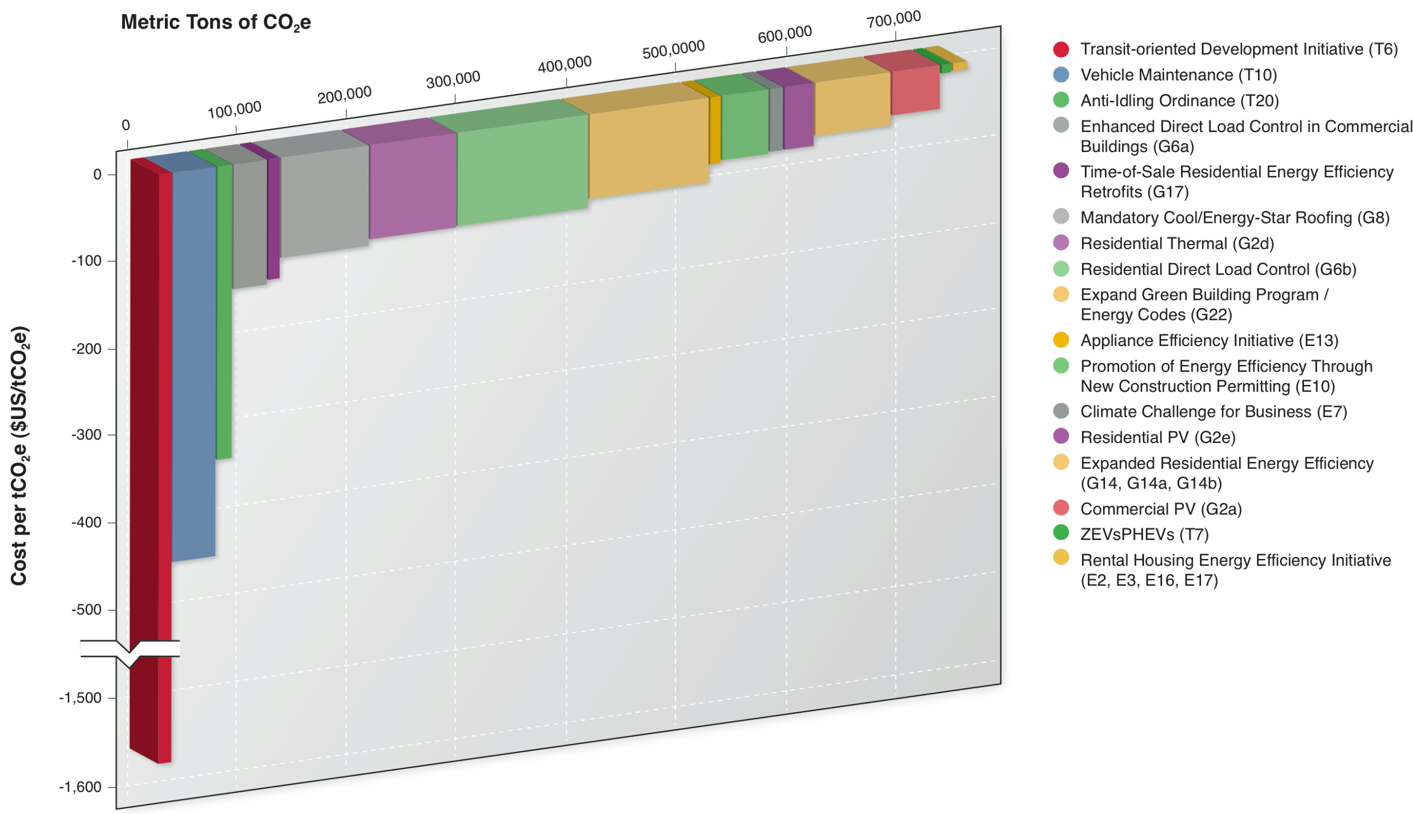

Figure 4

Notes

1) Economic analyses are performed from the community perspective. All rebates (federal, state, and local) have been considered.
2) Three of the top 20 measures (see **Figure 3**) do not have an economic analysis associated with them due to lack of data.

EXTERNAL FACTORS AND TRENDS BEYOND THE CITY'S INFLUENCE

There remain a number of external factors and trends, both positive and negative, which could affect the City's ability to achieve its GHG reduction goals. Global energy prices are continuing to rise as this report is being prepared. The rise in fossil fuel prices (coal and natural gas-fired electricity generation, gasoline and diesel transportation fuels, etc.) will further increase the cost-effectiveness of many energy efficiency and renewable energy technologies. Higher energy prices also could have negative impact on the strength of the economic recovery now underway. A certain amount of energy demand destruction took place during the recent recession and a similar occurrence cannot be ruled out in the future. In these cases, GHG reductions will occur even in the absence of specific City actions such as those evaluated in this report.

In addition, government actions taken at the national level to increase the efficiency of products such as appliances, automobiles, and electronics, plus technology advances in lieu of government actions, would achieve incremental but continuing reductions in both energy use and GHG emissions. Alternatively, population growth in the City, with or even without a large uptick in economic activity, could drive an overall rise in energy use and GHG emissions that possibly overwhelms reductions coming from the most well-designed climate mitigation strategies. However, a decline in population would likely lower overall City emissions.

NEXT STEPS AND CALL TO ACTION

We stress once more that the 2020 GHG reduction goal used for analysis in this report belongs solely to Westmoreland Associates and does not reflect any formal endorsement by the City of Tucson. It was created to allow us to demonstrate to the City the prospective GHG, energy and cost savings possible with the measures it presented us for analysis.

We want to emphasize the importance of the City establishing an updated GHG reduction goal so that climate mitigation planning, moved forward by this project, may proceed in the context of a new, formal emissions reduction target.

The City's updated goal should be framed in light of the growing concerns over the pace and consequences of continued GHG emission increases globally. Organizations ranging from local, state and national governments to international scientific bodies are calling for an 80% reduction in GHG emissions below 1990 levels by 2050 in developed countries.[1] The State of California has already adopted this goal, and it is now also the goal of the Organization for Economic Cooperation and Development (OECD) nations, including the United States.[2] [3]

We recommend that the City of Tucson consider adoption of a similar goal recognizing that there will be significant economic, social and environmental benefits to the community. These will occur as fossil fuel use is very profitably phased out through energy efficiency investments and the use of distributed and more sustainable energy sources – both of which generate more jobs per energy unit delivered than existing centralized, carbon-intensive energy systems.

Additionally, the City should continue to pursue development of a formal Climate Action Plan that integrates both mitigation and adaptation strategies for the community. Mitigation and adaptation strategies can be mutually reinforcing if properly designed and together can achieve economies not possible in isolated climate policy actions.

Finally, there will be several opportunities in the months ahead for the City to support GHG reduction efforts undertaken by others both within the City and throughout the region. These include programs developed and implemented at the University of Arizona and other schools, initiatives underway by community non-profit organizations and by the private sector, and by individual residents. In particular, there will be opportunities to coordinate climate action planning, both mitigation and adaptation, with those of surrounding municipalities, Pima County, and state and federal government agencies.

The City's already-impressive energy efficiency, renewable energy and GHG reduction accomplishments, folded into an aggressive, region-wide climate action strategy would deliver a climate resiliency and energy security program benefiting the City, its economy, and the social and community fabric of the entire region.

Introduction and Background

SCOPE OF WORK

The Scope of Work for this project required Westmoreland Associates to:

1. Conduct an analysis of approximately 60 greenhouse gas mitigation measures that includes but is not limited to:

    a. Quantification of the emissions reduction potential of each measure as a percentage of the City's overall reductions goal. The City's goal, created upon its endorsement of U.S. Mayors' Climate Protection Agreement (MCPA), was to achieve a 7% reduction in greenhouse gas emissions below 1990 levels by 2012.
    b. Total implementation costs of each measure and identification of the entities that bear the costs of implementation.
    c. Financial return or each measure and identification of the entities that realize the returns.
    d. Equitability of each measure (progressive/regressive, income/revenue neutral, etc.).
    e. Potential unintended consequences of each measure.

2. Identify the relevant indicators and data sources for each measure and gather baseline data, to ensure that the impact of each measure is quantifiable.

3. Clearly define implementation scenarios that are used to evaluate each measure.

4. Prioritize measures in terms of quick pay-backs and longer-term measures.

5. Complete and submit a report to OCSD staff within 60-90 days of the contract award date that includes items 1-4.

6. Attend meetings as needed with the City OCSD staff.

7. Submit information to the City necessary to satisfy the City's reporting requirements to both the U.S. Department of Energy and the U.S. Office of Management and Budget.

METHOD OF ANALYSIS

We began the analysis with a list of 54 potential greenhouse gas reduction measures assigned to us by the Office of Conservation and Sustainable Development (OCSD), along with a preliminary analysis that had been conducted earlier for most of these assigned measures. For those measures that had been the subject of earlier analysis, our assignment was to validate the assumptions and findings for each. In every instance where confidence was lacking in any assumption, data source, calculation, or implementation scenario we began a fresh analysis of the proposed policy measure. For new measures submitted for analysis we began by researching their previous use elsewhere and then created a scenario under which such a measure might be implemented in the City of Tucson.

For all mitigation measures examined we began by ensuring that there were valid and reproducible greenhouse gas savings at the unit level or equivalent. For example, a technology change such as implementation of a direct load control device such as a smart meter is expected to result in an average reduction in electricity use and associated greenhouse gas emissions based on empirical findings from other communities where the measure is already in place. From the unit level (one home installing one device) we proceeded to scale the expected energy and emissions reductions to the level of the implementation scenario chosen for the analysis (i.e. 40% of all homes by 2020).

We needed to identify a time frame likely for implementation of each measure once it received final administrative direction to proceed or Mayor and Council approval to begin. Due to the time likely needed for the deliberative process to take place for most measures and conclude in a decision to implement we rarely were able to project the beginning of energy savings, emissions reductions, cost savings, etc. until sometime in 2012.

As a consequence, this kept the cumulative emissions reduction potential of the measures evaluated extremely low relative to the City's MCPA goal. As explained below, we took the initiative to create a secondary goal - emissions reductions possible in 2020 - for purposes of evaluating the mid- to long-term potential of the measures beyond what would otherwise have been just a brief window of possible benefits.

An important starting point for our overall work was the findings contained in the October, 2010 update to Regional Greenhouse Gas Inventory prepared for the City by the Pima Association of Governments (PAG).

According to the PAG Inventory, a 7% reduction in GHG emissions below the City's 1990 level (5,461,020 tCO_2e) equates to 5,078,749 tCO_2e. This became the reduction target for emissions in 2012 in order to meet the MCPA goal. Without having a 2012 emissions value against which to compare reductions relative to the MCPA goal, we forecast that the City's emissions in 2012 would be 7 million tCO_2e. Thus the amount of emissions reductions sought was the difference between the projected 2012 level and the 7% below 1990 level – or 1,921,251 tCO_2e.

As noted, due to the accrual of emissions benefits from the measures analyzed not beginning in most cases until sometime in 2012 (if not later), their overall contribution to the MCPA goal was just 9%.

Given this, we wanted to extend the analysis beyond that required under the contract to illustrate the mid- to long-term potential of the measures evaluated. To make this possible given the absence of any GHG reduction goal for the City beyond 2012, we extended the "7% below 1990 levels" goal forward to 2020. We also generated a projected business as usual 2020 GHG emissions level for the City of Tucson of 7.34 million tCO_2e against which to evaluate the reduction potential of each individual measure. (See **Appendix F**)

As a result of our analysis, we determined that, if implemented, the measures analyzed would collectively contribute 50.2% of this 2020 GHG reduction goal. The representative contribution of each measure to the 2020 goal is highlighted in **Figure 3**.

Extending the 2012 MCPA goal to 2020 and determining GHG reductions in that year allowed us also to calculate implementation costs and net economic benefits to and through 2020. We have presented the greenhouse gas savings in 2020 (tCO_2e) and economic attributes (US$/ tCO_2e over the life of the analyzed program) of each measure separately the Analysis of Climate Action Measures below and displayed them graphically in **Figure 4**.

MEASURES ANALYZED

We were presented with an initial 54 proposed policy measures that we were charged to analyze in detail. The original matrix of measures is presented in **Appendix A**.

These 54 measures emerged from an earlier set of research efforts conducted for the City that at one point generated over 150 individual potential GHG reductions measures that other local government were considering or had adopted as part of their own climate action planning processes. The final list of 54 measures we received for analysis was developed by the City's OCSD in consultation with the City's Climate Change Committee, an advisory body to OCSD.

Upon examination of the 54 individual measures, and in consultation with OCSD, we decided in several instances to combine measures that were similar in description or which were in some cases redundant with each other. The end result was a shorter list of 42 unique measures that we then proceeded to analyze.

As we looked more closely at each of these measures, reasons emerged to eliminate a few more of them from additional consideration. For example, one measure to require use of "green" concrete ended up falling outside the scope of this project. Emissions due to cement production for use in Tucson arise from a manufacturing facility that is located outside the City's boundaries. As such, the emissions from this facility do not appear in the City's GHG inventory. We cannot therefore count emissions reduction from a less-CO_2e intensive cement manufacturing process occurring outside the City against the City's GHG reduction goals.

A similar measure, calling for the use of a less-CO_2e intensive asphalt production process, could not be included in our final results given that asphalt emissions were not originally included in the PAG inventory.

Another measure, one calling for government incentives to encourage increased deployment of electric vehicle (EV) charging stations was set aside as well. After a review of EV commercialization activities nationwide, we determined that the private sector is now well along in developing EV recharging infrastructure and that no additional governmental incentives, particularly in Tucson, were necessary.

Finally, as we looked at a number of other proposed measures among the original 54, several of them appeared to us to offer little to no potential for contributing to the City's GHG reduction goals. Therefore, these were simply noted in the analysis and we conducted no further energy/GHG or economic evaluations of them.

Westmoreland Associates recognizes that a final implementation scenario for any particular GHG mitigation measure will be decided through a public process. In the course of our work under the contract we are not attempting to make policy but simply to analyze one or more policy options with the greatest opportunity for success. We have provided the independent analyses that will allow public decision processes to proceed with as much valid, transparent and verifiable information as possible.

DATA SOURCES

We determined from the outset to obtain and use energy, price, and other relevant data that were as locally-specific to Tucson as possible. In some cases, state, national or global data sources were used to inform or validate conclusions reached. However, whenever possible we customized these data to the specific circumstances of the City's population, housing stock, commercial and residential construction patterns, land use plans, economic development, and energy prices.

We forecasted energy prices to 2020 using a mix of international, national and local variables, rather than simply extend national price forecasts to Tucson without consideration of historically-unique variations in energy costs in the City.

For greenhouse gas emissions calculations, we adopted the carbon-dioxide equivalent (CO_2e) measure that was initially used in the PAG Inventory. We calculated all GHG reductions in metric tons of CO_2e.

Further, we readjusted PAG's transportation sector emissions numbers for the 2006-2008 period. We did this to reflect actual state and national data showing reductions in vehicle miles traveled during this period, rather than the increases shown in a PAG model that was admitted to be insensitive to short-term changes in economic variables such as fuel price, and unemployment. (See **Appendix E**)

Our economic analyses were all conducted in today's dollars. We applied a economic multiplier of 1.5 when measuring net economic benefits of a particular measure. See **Appendix H** for more detail on the derivation of this multiplier and its use in our analyses.

CO-BENEFITS

For each measure analyzed, we identified those incidental co-benefits that are not normally quantified in an economic analysis of energy and environmental technologies or policy measures. These include benefits such as: lower health costs, reduced water demand, retained community wealth, noise abatement, reduced toxic emissions, reduction of barriers to and improvement in community economic and energy security, and increased economic competitiveness.

EXTERNAL FACTORS

There remain a number of external factors and trends, both positive and negative, which could affect the City's ability to achieve its GHG reduction goals. Global energy prices are continuing to rise as this report is being prepared. The rise in fossil fuel prices (coal and natural gas-fired electricity generation, gasoline and diesel transportation fuels, etc.) will further increase the cost-effectiveness of many energy efficiency and renewable energy technologies. Higher energy prices also could have negative impact on the strength of the economic recovery now underway. In this case, GHG reductions will occur even in the absence of specific City actions such as those evaluated in this report.

In addition, government actions taken at the national level to increase the efficiency of products such as appliances, automobiles, and electronics, plus technology advances in lieu of government actions, would achieve incremental but continuing reductions in both energy use and GHG emissions. Alternatively, population growth in the City, with or even without a large uptick in economic activity, could drive an overall rise in energy use and GHG emissions that possibly overwhelms reductions coming from the most well-designed climate mitigation strategies. Conversely, a decline in population (absent per capita increases in GHG emissions) would lower overall City emissions.

Lastly, we note that that there remains considerable scientific research over significant climate science unknowns such as ice sheet and permafrost melt. The acceleration of non-linear responses to rising GHG and temperature levels could result in the need for even more aggressive GHG reduction targets than those now being considered.

FINDINGS AND RECOMMENDATIONS

The following section presents the detailed analysis for each of the proposed mitigation measures we examined. Westmoreland Associates recommends that priority attention be given to those which 1) result in the most significant reduction in greenhouse gas emissions, 2) have the most attractive net economic benefit, and 3) those which have the most compelling array of social, economic security, public health, and other co-benefits.

Finally, because the cumulative remissions reduction potential of all measures examined falls far short of the recommended GHG emissions target for 2020, the City will need to identify additional measures – or expand/accelerate the implementation scenarios we use- in order to achieve the intended GHG mitigation goal.

We want to emphasize the importance of the City establishing an updated GHG reduction goal so that climate mitigation planning, moved forward by this project, may proceed in the context of a new, formal emissions reduction target.

The City's updated goal should be framed in light of the growing concerns over the pace and consequences of continued GHG emission increases globally. Organizations ranging from local, state and national governments to international scientific bodies are calling for an 80% reduction in GHG emissions below 1990 levels by 2050 in developed countries. The State of California has already adopted this goal, and it is now also the goal of the Organization for Economic Cooperation and Development (OECD) nations, including the United States.

We recommend that the City of Tucson itself consider adoption of a similar goal recognizing that there will be significant economic, social and environmental benefits to the community as fossil fuel use is very profitably phased out through energy efficiency investments and the use of distributed and more sustainable energy sources – both of which generate more jobs per energy unit delivered than existing centralized, carbon-intensive energy systems.

Endnotes:

[1] Cambridge Econometrics. http://www.newscientist.com/data/doc/article/mg20427373.400/ce_new_scientist_report.pdf

[2] See the website of California Air Sources Board, including the wedge strategy analysis for reaching 80% reduction by 2050 conducted by the National Resources Defense Council (NRDC) at: http://www.arb.ca.gov/msprog/zevprog/2009zevreview/102809ghgmeeting/mui.pdf

[3] See EPA Administrator Lisa Jackson's statements to the OECD, 2009, at: http://www.oecd.org/dataoecd/59/54/42897624.pdf. The OECD's 2008 analysis found that emissions would likely rise 52% from 2008 levels by 2050 without concerted actions, which could instead reduce emissions 40% - see http://www.arb.ca.gov/msprog/zevprog/2009zevreview/102809ghgmeeting/mui.pdf.

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General Energy Efficiency Options

- Promotion of Energy Efficiency Through New Construction Permitting (E10)
- Rental Housing Energy Efficiency Initiative (E2, E3, E16, E17)
- Climate Challenge for Business (E7)
- Appliance Efficiency Initiative (E13)
- City of Tucson Energy/Water Performance Contracting (E12)
- Community Climate Challenge (E14 & E23)
- Residential Solar Street Lights (E22)

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Measure: Promotion of Energy Efficiency Through New Construction Permitting (E10)

Offer rebates on new home construction permits for homeowners/developers that utilize Energy Star appliances including:

a. Refrigerators
b. Dishwashers
c. Clothes Washers
d. Central Air-Conditioning.

The Committee asks Westmoreland to analyze mandating the use of energy efficient AC units only. That analysis can be found at the end of this section; the summary is in the table below.

COT ARRA RFP Summary (MANDATE ENERGY EFFICIENT AC UNIT):

Emission reduction potential by 2020:	45,111 tCO_2e
Percentage of goal (2012):	0.47%
Percentage of goal (2020):	2.0%
Total annual average implementation costs:	$1.7 million over 10 years
Entity that bears the costs of implementation:	Purchasers of AC units
Savings per tCO_2e over life of program:	$74 / tCO_2e (Net savings to community)
Net annual savings:	$1.7 million over 20 years
Entity that realizes the financial return:	Homeowner
Equitability (progressive/regressive, income/revenue neutral, etc):	Income neutral
Potential unintended consequences:	None Identified

Background information:

The previous reporting to the City of Tucson on this measure confused two distinct energy efficiency programs. The primary program researched was the Ft. Collins, CO based Zero Interest Loans for Conservation Help (ZILCH loans). This program allows homeowners to qualify for no-interest loans to help cover the capital costs for energy efficient home improvements. The maximum overall loan amount is $2,300, which cannot exceed more than 80% of the project cost, for energy efficiency and energy conservation.[1] The cost of the projects are calculated on the total amount less rebates offered through the utility company's Electric Efficiency Program (EEP).[2]

The second program previously researched was another Ft. Collins based incentive in which residential building permits are discounted for utilizing "system analysis" programs to demonstrate the new home meets local energy codes.[3] This incentive does not necessarily translate to home energy savings, as it is just a way to illustrate that local codes have been met.

Nevertheless, the US Green Building Council lists permit fee reductions as one way to spur energy efficiency in new construction.[4] Cities around the nation are taking notice. For example, the City of Ashville, NC has a "Green Building Incentive" program for residential buildings.[5] Also, San Diego, CA has s similar program where not only are permit fees reduced if certain criteria are met, but plan check times are reduced.[6] Incentivizing energy efficiency upgrades through rebates on building permits is a relatively low-cost and revenue-neutral path to increasing technology uptake while decreasing local emissions.

Description of Measure and Implementation Scenario:

Offer rebates on new home construction permits for homeowners/developers that utilize Energy Star appliances including:

a. Refrigerators
b. Dishwashers
c. Clothes Washers
d. Central Air-Conditioning.

To make the program cost neutral, increase the City of Tucson building permit fee schedule to cover costs of the rebates. The median cost of a new home in Tucson is approximately $157,000.[7] Given the City of Tucson residential building permit fee rate schedule, the resulting building plan review revenue per home is approximately $2,000.[8] Inline with the City of Ashville's payment schedule, the permit fee shall be paid in full and the rebates will be credited at the time of certificate of occupancy once the energy appliance installation is verified.

The implementation scenario assumes that participation will increase from 25% to 75% over the course of the next decade. New home construction is estimated to average

3,500 with an occupancy rate of 90% consist with other analyses in this report.

Business As Usual:

There are currently over 19,000 Energy Star qualified homes in the greater Tucson area, with over 700 qualified during October 2009 through September 2010.[9] Therefore, it is estimated that at least 25% of homes are already utilizing energy efficiency measures. Of course, if the Green Building Incentive program is initiated, it is assumed that these homes will utilize the program but their resulting savings will not benefit the City's abatement efforts.

Has the Measure been implemented elsewhere and with what results?:

The City of T. Collins, CO has implemented a $75 "Fee Reduction" to all residential building permit fees for those who use either the E-Star or ENERGY SCORECARD for showing that the new build complies with the local energy codes.[10] However, as described above this program doesn't necessarily lead to energy savings for the homeowner. The Cities of Ashville, NC and San Diego, CA have implemented different programs under the same title of "Green Building Incentives". Although neither program exactly mimics the measure analyzed herein, the theory is the same- to spur energy efficiency and energy conservation measures by incentivizing the building permit process. In the case of Ashville, the rebates, paid at the time of certificate of occupancy, are relatively small financial incentives for energy efficiency.[11] San Diego not only offers financial incentives but expedited permitting times as well.[12] Documentation on GHG savings associated with these programs could not be found.

Energy/Emission analysis:

The implementation scenario assumes that participation will increase from 25% to 75% over the course of the next decade and that all homeowners/developers install all four appliances:

a. Refrigerators
b. Dishwashers
c. Clothes Washers
d. Central Air-Conditioning (CAC).

The energy savings associated with these appliances are calculated from the savings and costs outlined by the Energy Star Program and are as follows:[13]

Appliance	Cost	Annual Energy Usage (kWh)
Refrigerator		

Energy Star	$1,180	507
Conventional	$1,150	634
Dishwasher		
Energy Star	$550	294
Conventional	$538	368
Clothes Washer		
Energy Star	$750	536
Conventional	$492	787
CAC (4 ton)		
Energy Star	$3,735	5,106
Conventional	$3,179	6,779

New home construction is estimated to average 3,500 with an occupancy rate of 90% consistent with other analyses in this report. Energy costs are assumed to rise per the energy forecast included in the appendix of this report, and the energy savings difference between the Energy Star appliance and the conventional are assumed to remain constant throughout the life of the program.

GHG emission abatement calculations were performed assuming a 10-year life to all appliances covered by the permit fee rebate, and only those emissions above and beyond the 25% of homes estimated to already be installing Energy Star are counted (ie, beyond business as usual- BAU).

To increase from the current 25% of new builds installing Energy Star appliances to 75% by 2020, 142 occupied homes have to be added to the program per year. The total participating new homes will be the amount added (ie, 142 in the first year, 284 the second year, etc.) plus the estimate 25% already participating (ie, 788).

With the above listed energy savings and the quantity of new homes per year needed to hit the 2020 target of 75%, the resulting energy savings in 2020 is over 16.5 million kWh resulting in an abatement of 14,181 tCO_2e.

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[14]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Promotion of Energy Efficiency Through New Construction Permitting		
Contribution of E10 Promotion of Energy Efficiency Through New Construction Permitting (2020):	14,181	tCO_2e

% 2020 Contribution of E10 Promotion of Energy Efficiency Through New Construction Permitting:	0.63	%

Economic analysis:

The economic analysis assumes a rebate structure as follows:

Appliance	Rebate
Refrigerator	$20
Dishwasher	$10
Clothes Washer	$200
AC (4 ton)	$300

Therefore, the total amount of rebates, offered at the time of completion, for an individual home is $530. The City would need to cap the total amount of rebates offered such that the program remains revenue neutral. The program would be suspended for the balance of the year once funds are expended. To cover the costs of the program the residential permits fees would increase from the current rate of approximately $2,000 by $192 in the first year of the program increasing incrementally to $902 in 2020.

Given these inputs, three different costs/savings indicators are calculated. The first impact is the cost to those not participating in the program to cover the rebates. The second is the cost savings to the participants by way of lower energy bills over the 10-year life of the appliances. And, the third is the net cost between the two. All calculations are based on what happens beyond BAU.

The total costs to run the program through 2020 (ie, those costs to cover the rebates) are $8.3 million. The emissions abated over the life of all appliances installed under the program totals 141,814 tCO_2e. The net annualized cost to run the program is $830K. The cost per tCO_2e to run the program is:

- ***Cost*** per tCO_2e = ***$58.57 /*** $\boldsymbol{tCO_2e}$

The savings to the participants by way of lower energy bills over the 10-year life of the appliances total over $16.5 million. The resulting savings per tCO_2e to homeowners are:

- ***Savings*** per tCO_2e = ***$116.42 /*** $\boldsymbol{tCO_2e}$

The net savings to the community over the life of the appliances totals over $8.2 million, which calculates to the annualized savings over 20 years to $410K. The net savings per tCO_2e to the community are:

- ***Savings*** per tCO_2e = ***$57.86 /*** $\boldsymbol{tCO_2e}$

We use the 1.5 multiplier to estimate the net positive impact on the City of Tucson economy from energy or water savings. This results in a net economic impact estimate of $12.3 million.

Co-benefits:

The co-benefits include Increased demand for new technology and a more stable energy grid by lowering demand (especially peak demand associated with AC units)

Equitability:

There are no apparent equitability issues.

Potential unintended consequences:

None identified.

AC ONLY ANALYSIS:

At the request of the Climate Change Advisory Committee, Westmoreland analyzed mandating the installation of Energy efficient AC units. Using the numbers above for the AC unit and mandating that all new home construction utilize an energy efficient AC unit with a life of 10-years (assumed to be, on average, 3,150 homes per year), the following are the outputs:

Total tCO_2e over life of program (2011-2030): 451,108
Total costs to implement (capital) (2011-2020): $17.5 million
Total savings as a result of lower energy usage (2011-2030: $50.8 million
Net savings: $33.2 million
Net savings per tCO_2e: $74
Total capital costs per tCO_2e: $38.82
Net impact to community using economic multiplier of 1.5: $49.9 million.

General Note: All references retrieved October through January of 2011 unless otherwise noted.

Endnotes:

[1] http://www.fcgov.com/utilities/img/site_specific/uploads/ZIL_Project_Table.pdf

[2] http://www.fcgov.com/utilities/img/site_specific/uploads/eep.pdf

[3] http://www.fcgov.com/building/energy-code.php

[4] http://www.eoearth.org/article/Green_Building_Standards

[5] http://www.ashevillenc.gov/uploadedFiles/Departments/Buidling_Safety/Permit%20Fees%20for%202010-2011.pdf

[6] http://www.co.san-diego.ca.us/dplu/greenbuildings.html

[7] http://azstarnet.com/real-estate/article_e712a40b-7723-50ac-b742-88d4107a12b7.html

[8] Derived from: http://cms3.tucsonaz.gov/files/dsd/DevStd105.pdf

[9] http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showAreaResults&s_code=AZ&msa_id=338

[10] http://www.fcgov.com/building/energy-code.php

[11] http://www.ashevillenc.gov/uploadedFiles/Departments/Buidling_Safety/Permit%20Fees%20for%202010-2011.pdf

[12] http://www.co.san-diego.ca.us/dplu/greenbuildings.html

[13] Spreadsheet with assumptions are downloaded from: http://www.energystar.gov/index.cfm?c=products.pr_find_es_products

[14] PAG Regional Greenhouse Gas Inventory- 2010

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Measure: Rental Housing Energy Efficiency Initiative (E2, E3, E16, E17)

Design and implement a City-wide ordinance establishing requirements for landlord disclosure of energy use for rental housing, creating a City-sponsored energy efficiency awareness program, and establishing a minimum energy efficiency retrofit requirement upon transfer of rental property.

Energy savings and greenhouse gas emissions reductions will be a function of the effectiveness of the awareness and landlord disclosure initiatives as well as the annual transfer rate for rental housing properties within the City.

Emission reduction potential in 2020:	15,650 tCO_2e/yr.
Percentage of goal (2012):	0.1%
Percentage of goal (2020):	0.7%
Total annual average implementation costs:	$910,000
Entity that bears the costs of implementation:	Rental unit owners
Cost/Savings per tCO_2e:	Savings $9/tCO2e
Net annual savings 2012-2020:	$86,667
Entity that realizes the financial return:	Renters or landlords
Equitability (progressive/regressive, income/revenue neutral, etc):	Could be progressive if renters obtain most of the financial benefits
Potential unintended consequences:	Landlord resistance

Background information:

Nationwide, sixty-one percent of the residential rental housing units that will exist in 2030 have already been built.[1] There is no longer that best, first chance to build these homes and apartments to meet modern building energy efficiency standards. However, we know from countless examples across the U.S. that modest investments in energy efficiency retrofits in existing housing stock can reduce carbon emissions and cut utility bills by as much as 20 to 30 percent.[2]

Achieving energy efficiency in rental housing poses a different set of challenges than for owner-occupied homes. One major barrier to investment in energy efficiency for rental housing is known as the split incentive – when those responsible for paying energy bills are different than those making capital investment decisions.

Split incentives are common in rental properties where tenants pay the energy bills, but owners pay for the upgrades. Building owners rarely invest in energy efficiency improvements when renters are those who would see the savings. And tenants seldom invest in a property they do not own even if they would see the benefits of lower energy bills.

Rental housing owners are not a centralized group, making it a challenge to disseminate information and resources and regulate energy efficiency in the rental sector. Engaging tenants around energy efficiency is a challenge due to tenants often not having the necessary information to make regarding improved energy efficiency and the cost savings that would accrue to them. Continuing education and outreach to tenants often helps address some of the behavioral energy use issues.

Programs to improve energy efficiency in rental housing generally fall into a few discrete categories: (1) programs funded by energy utilities; (2) programs initiated by rental owners combined with energy education efforts directed at tenants; (3) local government requirements for energy efficiency upgrades upon resale; and (4) energy efficiency audits and subsequent improvements provided by community organizations, often non-profits or government housing authorities using state or federal grant funds.

Energy efficiency policy approaches in the rental housing sector will differ depending on who pays for utilities. Many multi-family rental units have a single meter, meaning that individual unit's energy use is not measured or specifically billed to the tenants. In this case, landlords pay the utility charges and include a pro-rated charge to all tenants in their monthly rent.

There is no incentive for individual tenants to lower consumption or even see what their consumption amounts to over any billing period. In some cities, this percentage can be as high as 80%. In the absence of utility data on the percent of individual v. bulk metering in the Tucson rental housing sector, we estimate 75% of all rental units to be bulk metered.

Those rental units where tenants are individually billed for utilities are open to a different set of incentives and policy options than those that are common-metered and billed. This initiative includes actions we believe most effective in achieving energy efficiency savings in each of the two categories of rental utility billing.

As smart grid technologies evolve, utilities may install or at least offer individual meters to rental units that are not presently metered. An investment in smart grid technology could generate incentives for renters to save energy depending on how the smart grid program is structured. We are not including an analysis of such an option as it appears premature within the City at present. Should this change over time, it will be worth revisiting the rental housing sector to see if additional energy savings and greenhouse gas emission reductions are available.

Status Quo / Business as Usual:

The Tucson Electric Power Company does provide some general billing information (highest/lowest monthly bill, 12 month average) for any property in the City for a year prior to an inquiry. However disclosure is not automatic nor does it include specific units of energy consumption such as kWh. [3]

Both the City of Tucson and the Tucson Electric Power company sponsor energy efficiency education programs targeted broadly across the community. We could find no programs specifically designed to address the disincentives to energy efficiency upgrades in the rental housing sector. In the absence of this initiative, business-as-usual would see little improvement in the overall energy efficiency of the rental housing stock in Tucson, with lost economic opportunities and other co-benefits described below.

According to the Regional Greenhouse Gas Inventory update of October 2010, natural gas is a small component of City greenhouse gas emissions, contributing about 5% to the 2008 total.[4] While general energy efficiency awareness, disclosure, and retrofit on transfer may likely yield reductions in natural gas usage in rental units with gas service, this initiative focuses solely on the cost and greenhouse gas savings potential of reduced electricity use only.

Description of Measure and Implementation Scenario:

This “Rental Housing Energy Efficiency” initiative combines three elements:

1) An energy use disclosure requirement for rental housing where tenants are responsible for their own energy costs;

2) A more aggressive energy efficiency awareness and outreach program championed by the City's housing authority and supported by landlords as well as the Tucson Electric Power company and Southwest Gas; and

3) A minimum energy efficiency retrofit requirement upon ownership transfer of rental property.

More specifically, the initiative involves:

1) Directing City staff to work through the Pima Association of Governments and with the support of the local utilities to craft an outreach program aimed at delivering quality energy efficiency advice to renters and landlords within the City.

2) Enactment of an ordinance that requires a minimum level of energy efficiency upgrades upon transfer, similar to the Burlington VT model described below.

3) Enactment of an ordinance that requires landlord disclosure of past monthly energy consumption and cost data to each prospective tenant prior to rental.

Has the Measure been implemented elsewhere and with what results:

Although the three program components identified above have been individually implemented in various jurisdictions nationwide, no program has combined the three elements into a single initiative. Individual experiences are as follows:

Energy Disclosure Requirement

Various locales throughout the U.S. have implemented energy consumption disclosure requirements in the rental-housing sector. One of the earliest rental disclosure programs was enacted into law in Maine in 2006.[5] This law requires that any landlord of residential property provide potential tenants a residential efficiency disclosure statement containing information about heating systems, insulation levels, windows and doors, and appliances.

The landlord is required to provide the statement to any person who, in person, requests a copy of the statement and said statement is to be posted in a prominent location at the property being offered for lease or rent.

The law further requires that upon entering into a contract with a tenant or prior to having received a deposit for the rental property, the landlord must provide the tenant the disclosure statement that must in turn be signed by the tenant. The signed, disclosure statement is retained by the landlord for a minimum of seven (7) years. The form also highlights an existing law by which renters can get the prior year's electric and gas costs by calling utility companies.

The disclosure statement is intended to help prospective tenants make informed decisions about energy consumption prior to renting a property.

This law also required the preparation of energy efficiency standards that are suggested for rental properties used as a primary residence. They remain voluntary at the present time and are intended to provide guidance to landlords seeking to improve the efficiency of rental properties. Together, the disclosure form and efficiency standards were designed to result in improved energy efficiency over time, as landlords and renters become more knowledgeable about ways to improve building efficiencies.

While there was no evaluation component built into the Maine law, there is anecdotal evidence of energy efficiency improvements being made in rental housing as a result of the disclosure requirement.[6]

Different programs vary regarding the information to be disclosed. Some require full-scale energy use benchmarking using Energy Star or other building energy performance methodologies. Others simply require that the monthly energy use (electricity/natural gas) be provided to tenants prior to a rental transaction.

Mandatory disclosure policies are an important tool in the toolbox to incentivize cost-effective energy savings. To lead to action, the disclosure information should also assist renters by recommending appropriate energy-efficiency improvements, providing financial analyses, referring to government or utility incentives, referencing financing opportunities, and providing options for more detailed analysis of an apartment or building's energy use.

Energy Efficiency Awareness

An energy efficiency awareness program implemented at a public housing complex in Minneapolis involved the building owners conducting a workshop for tenants to talk about ways that they could reduce their energy usage through behavioral changes. The landlord offered a one-time $25 rental discount for those who attended and installed the free energy efficiency materials that were distributed.

The focus of the workshop was low-cost and no-cost measures to save energy, such as turning off lights and electronics, using power strips, taking shorter showers, and installing basic materials like CFLs, window insulation kits and weather stripping.

The workshop was hosted by the building caretakers, who were interested in a workshop not only for the topic but also as a way to bring people in the building together. However, there were mixed results. Out of twelve households that attended the workshop, only two people installed the free materials, even with the extra incentive. The lesson learned in this example was that a single workshop and a small one-time rent reduction was insufficient incentive to elicit renter participation.

Time of Sale Minimum Energy Efficiency Ordinance

The City of Burlington VT has enacted a time of sale minimum energy efficiency ordinance for rental housing.[7] The ordinance specifies several minimum upgrades to a building's energy efficiency that are required upon transfer. The total cost of the required improvements must not exceed 3% of the sales price as listed on the property transfer tax return or $1,300 per rental unit, whichever is less.

After this, the ordinance only mandates the installation of measures that have a simple payback of seven years or less. Simple payback is the cost of doing the measure divided by the yearly energy savings.

The City of San Francisco also has an energy efficiency upgrade requirement applicable to rental housing.[8] The San Francisco program requires an inspection and improvement in building energy efficiency prior to sale. A report from Earthfuture.com on the San Francisco program states that "the cost to San Francisco's city budget has been nil, and the cost of enforcement through the city's Housing Inspection Services Division has been very inexpensive."[9]

While not a time-of-sale energy efficiency measure, Ordinance 7726 recently enacted by the **City of Boulder, Colorado** establishes minimum energy efficiency upgrades for most rental housing units in the city.[10] Under the program, landlords are required to make improvements that could include installing energy-efficient appliances, sealing ducts or better insulating. Rental properties are required to achieve 100 "points" -- including two points of mandatory water conservation -- based on a lengthy list of possible improvements.

Property owners could opt out of the points system by proving the energy efficiency of their rental units through a Home Energy Rating System test. Buildings have to score high enough to equal the efficiency of the points system. The costs for making energy upgrades would vary widely based on the age and overall condition of rental properties.

The city of Boulder recently completed testing on seven homes and found that reaching the 100-point threshold cost between $675 and $3,243 each. The city estimates that a landlord's investment of $2,000, for example, would cost an additional $17 a month over 15 years.[11]

Energy/Emission analysis:

Due to the absence of whole-system implementation of this initiative, expected energy savings are difficult to estimate and thus exhibit a range of uncertainty. This uncertainty and the assumptions we use are made explicit in the analysis that follows.

The 2010 American Community Survey (ACS) for the Tucson *urbanized area* indicates 111,048 occupied housing units paying rent.[12] City-data.com shows a rental-occupied housing number for the City of Tucson of 89,717 in 2009.[13] As the ACS number includes rental-housing units outside the city limits, we are using the City-data.com number, rounded to 89,000 (due to current, historically high vacancy rates) as our conservative estimate of rental housing units in the City.

Average electricity consumption for a Tucson household is approximately 11,000 kWh/year.[14] Absent an electricity consumption value specific to rental units, we are assuming that rental units (smaller in average size than single family houses) consume 9,500 kWh/year.

The first component of this Rental Housing Energy Efficiency measure, the energy disclosure requirement, is similar to the deployment of a smart meter in that it provides a household with energy consumption values that are anticipated to drive behavior change in the form of reduced energy consumption. Smart meters do this via real-time information available to consumers. A year-long Department of Energy study of Illinois' Commonwealth Edison's smart meter program showed an average 10% reduction in home energy use after the meters were installed.[15]

[There is a separate GHG reduction measure addressing residential smart meters elsewhere in this report.]

We anticipate the reduction in energy use per household as a result of energy disclosure in rental units without smart meters to be similar to that achieved with a smart meter program. Thus, we are assuming an energy savings reduction of 10% of the annual average consumption (or 950 kWh/year).

We estimate, based on trends in other cities, that 75% of the rental housing market in Tucson includes energy costs as part of the monthly rent. Of the 89,000 rental units estimated to be currently occupied in Tucson, only 22,250 units would have individual electricity meters. Further, we conservatively assume that only 25% of the rental households (or 5,562) participate in the form of energy-reducing behavioral change based on disclosure information.

Using the expected annual electricity savings of 10% for these 5,562 participating rental households yields an annual energy savings of 5,283,900 kWh [5,562 participants x 950 potential kWh savings per participating rental unit].

We estimate that 20% of the 5,562 targeted rental participants will be engaged at the end of 2012, with full implementation by the end of 2016. First year savings therefore would amount to 1,056,780 (5,283,900 x .20). By the time of full implementation this measure will result in cumulative savings of 50,058 kWh.

[Should energy disclosure information elicit participation of the full 22,250 rental households with individual metering, at the identical 10% annual energy use reduction, there would be a maximum achievable annual energy savings on the order of 21,137,500 kWh, and 211,375,000 kWh savings cumulatively over ten years.]

The energy efficiency awareness campaign proposed as a component of this measure is intended to help ensure the results projected above. No independent, additional energy savings are projected in an effort to avoid double counting, however this education effort in collaboration with key stakeholders is seen as crucial to the success of the measure.

Finally, there will be additional energy savings and GHG reductions as a result of an energy efficiency requirement at the time of rental property transfer. Again, to avoid double counting, we only work with the percentage of the rental housing stock believed to be single-metered at present, or 66,750 rental units. We apportion the projected rental real estate transfers similarly.

In 2009, there were no “arms-length” transactions of 100+ unit properties and only two properties of 40-100 units traded hands.[16] Eleven 12 to 39-unit buildings changed owners. As of early 2009, there were approximately 25 major apartment properties in the process of foreclosure in Tucson. Thus, picking mid-point ranges for the transfers listed above, we estimate a total of approximately 415 rental units changing hands in 2009, the last year for which actual data are available.[17]

If 75% of those are single-meter units, then we estimate 311 of them would have benefited from energy efficiency upgrades that a time-of-sale ordinance would deliver.

For the three years prior to 2009, rental housing property transactions were 2-5 times the 2009 number. Transactions of single-metered rental units began falling from an estimated 2,400 units in 2006 to the estimated 311 in 2009.[18]

For the period to 2020, we estimate that an average of 700 units of single-metered rental housing will change hands per year based on continuing lag in recovery of the rental housing market, current home and likely future home foreclosure rates, and lower rental vacancy rates.

Using the low end of the Affordable Housing Finance account cited earlier, we assume a modest 20% improvement in energy efficiency upon retrofit. These retrofit improvements are generally fixed to the premises (apartment envelope, windows, heating/cooling units, etc.) so would continue annually as renter turnover occurs. Thus for the first and each succeeding year the average annual rental housing energy savings per unit would be 1,900 kWh (20% x 9500 kWh/unit/year).

The total expected annual energy savings from this three-component initiative are the following, assuming all energy saved is electricity:

2012:

Energy disclosure requirement: 1,056,780 kWh
Efficiency transfer requirement: 700 x 1,900 = 1,330,000 kWh
Total: 2,386,780 kWh

2020:

Energy disclosure requirement: 5,283,900 kWh
Efficiency transfer requirement: 700 x 1,900 x 9 yrs = 11,970,000 kWh
Total: 17,253,900 kWh

Cumulative savings 2012-2020:

2012 GHG emissions reductions: 2,386,780 kWh x 2 pounds/kWh = 4,473,560 pounds (divided by 2,205 pounds/metric ton) = 2,165 tCO_2e.

Emissions savings in 2020 amount to 17,253,900 kWh x 2 pounds/kWh = 34,507,800 pounds (divided by 2,205 pounds/metric ton) = 15,650 tCO_2e.

Accumulated emissions savings by 2020: 87,834 tCO_2e.

Climate change impact summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	2,165 in 2012; 15,650 in 2020

Economic analysis:

Initiative Costs

The cost of the energy disclosure requirement would be borne by landlords but is expected to be nominal. An energy awareness campaign would be expected to build on existing City and utility initiatives, combined with involvement of apartment owners and realtors.

The costs should be nominal though more proactive promotion of energy efficiency benefits may initially require redirection of existing staff resources to build the coordinated outreach program needed to achieve benefits from the disclosure requirement.

The mid-point cost in Boulder's 100 point program suggests an average of $2,000 to upgrade each rental unit to achieve Boulder's 100 point goal.[19]

We project an average $2,000 cost to upgrade each rental unit upon transfer to achieve a 20% reduction in energy use. Actual costs for units needing the least amount of efficiency upgrades or those offering the most low-cost potential for efficiency upgrades suggest to us that the projected $2,000 cost per unit should be designed in as a cost cap pending evaluation of early program results.

Therefore we estimate that the average cost per retrofit in Tucson would be on the order of $1,300/unit. This cost per unit could be borne initially by the landlords and recovered via reduced energy costs to the same landlords. Retrofits of an average of 700 units/year would have a capital cost of $910,000/year.

Initiative Savings

Local utility rates in Tucson are tiered based on amount consumed and time-of-use. We are using an average of $0.08 kWh in 2011 rising 2.4%/yr as the cost/kWh saved.

Thus, energy cost savings in 2012 would be $195,525; by 2016 annual cost savings are $1.075 million; by 2020 the annual cost savings are $1.709 million.

Net Economic Impacts

Initiative Costs to 2020:	$8.19 million
Initiative Savings to 2020:	$8.97 million
Net Cost:	$0.78 million

With a 1.5 multiplier of the energy savings, the positive net impact is projected at $1.17 million.

The savings per tCO_2e is $0.78 million divided by 87,834 = $9.

Extended to 2036, the Initiative's accumulated savings reach $62 million.

Co-benefits:

Co-benefits include the following that largely depend on the supply and demand for rental housing at any given time:

1) Landlords or tenants will pay less for energy, leaving more of their disposable income available for expenditures that may have a high multiplier for the Tucson region.

2) If supply of rental housing exceeds demand, landlords may not be able to charge more for energy efficient rentals, effectively reducing the total rental costs for tenants (total costs being rent plus utilities.)

3) Tenants are better positioned to withstand periods of temperature extremes at the same or lower cost of energy, potentially reducing healthcare costs.

4) If regional electricity demand is reduced, regional electricity rates are likely to increase less since new power plants may not be required or may be delayed.

Equitability:

The measure is generally progressive in that it ultimately results in lower energy bills for renters, a category of Tucson households without access to many of the traditional energy efficiency resources and financing mechanisms available to homeowners.

Potential unintended consequences:

Most landlords of single-metered rental housing units or complexes should be able to understand the economic benefits accruing to them from energy efficiency retrofits to their buildings. However, there may be initial resistance from some landlords due to unfamiliarity with energy efficiency measures generally as well as a possible preference for their traditional use of energy cost pass-throughs via rent.

There will need to be an initial outreach and education element to this activity as well as information on resources available to conduct quality energy efficiency retrofit work.

Endnotes

[1] "Getting Serious About Energy Efficiency in Affordable Rental Housing." *Affordable Housing Finance*, April 2008.

[2] Ibid.

[3] UA student report for Tucson Electric Power, 2009.

[4] Pima Association of Governments, "Regional Greenhouse Gas Inventory," October 2010.

[5] Maine State Housing Authority, at: http://www.mrema.org/documents/Notice_2006-07_5-1-2006.pdf.

[6] Portland Press Herald, December 10, 2006, at: http://business.mainetoday.com/news/061210apartments.html.

[7] City of Burlington Electric Department, at: https://www.burllingtonelectric.com/page.php?pid+43&name=time_of_sale#applicability

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Measure: Climate Challenge for Business (E7)

Enhance Tucson business participation in voluntary greenhouse gas mitigation reductions, using EPA's Climate Leader program as a model and building on early successes of the City's Green Business Certification Program with a goal of growing private sector voluntary efforts in climate action throughout the City.

Emission reduction potential by 2020:	13,953 tCO_2e / yr.
Percentage of goal (2020):	0.6%
Total annual average implementation costs 2011-2020:	$1.08 million
Entity that bears the costs of implementation:	City of Tucson or NGO program administrator ($450,000) and businesses that invest $1.3 million
Cost/Savings per tCO_2e *over lifetime of investments*:	Savings $72 / tCO_2e
Net annual savings in 2020:	$443,459
Entity that realizes the financial return:	Tucson businesses
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	If participating businesses do not follow through with their commitments to the program, program funds will be wasted

Note:

Financial analysis of this measure assumes that a typical business will invest $26,000 and achieve energy savings of ~3X the investment, including savings from voluntary behavior changes by business personnel resulting from program participation.

Over the eight-year program period analyzed (2012-2019), 400 businesses invest $10.4 million, the program administration costs $3.6 million, and businesses save over the lifetime of their investments ~$31 million (assuming a 10-year life of the investments). After investment costs and City program administration costs, net savings are projected at $17.1 million.

The analysis is done assuming all savings are electricity costs; the reality will be that savings include water, natural gas and vehicle fuel costs.

Background information:

The U.S. Environmental Protection Agency (EPA) began the Climate Leaders program in 2002, creating a voluntary program for organizations to complete a corporate-wide greenhouse gas inventory, set a reduction goal and meet that goal.

Climate Leaders was a successor program to Climate Wise that EPA administered from 1994-2000. At that time, Climate Wise was folded into the EPA Energy Star program.

The EPA has recently announced that it will phase down services it offers under its Climate Leaders program over the coming year and encourage participating companies to transition to state or non-governmental programs.[1]

Factoring into the agency's plans for the program are the many new developments in regulatory and voluntary programs that address greenhouse gas (GHG) emissions, including the first-ever mandatory GHG reporting rule that took effect on January 1, 2010.

In addition, several states and non-governmental organizations (NGOs) now offer climate programs that are now robust enough to serve companies in the Climate Leaders program.

As EPA phases down services the agency provides under the program – including technical assistance and setting greenhouse gas reduction goals – the agency will also take steps to assist the transition of the partners into non-federal programs that will allow them to go above and beyond mandatory reporting requirements to meet their goals. The agency will work with these programs to continue to stay involved in important initiatives related to corporate greenhouse gas accounting and to support companies' actions to reduce their GHG emissions.

The City of Tucson has created a Green Business Certification program that is already having success in working voluntarily with local businesses to reduce energy use and in the process lower their greenhouse gas emissions.

Goodmans Interior Structures piloted the Green Business Certification Program in 2009-2010 with a series of energy, water, waste, and pollution prevention audits. Goodmans occupies a 33,000 sq. ft. facility built in 1999 that is comprised of a 2-story office/retail showroom and an adjoining warehouse.

The energy evaluation illustrated how Goodmans was able to achieve a 13% reduction in their electricity use through behavioral and no-cost changes such as turning off bathroom lights when not in use, turning off vending machine lights (a $200 a year savings!), and consolidating office space onto one floor.

Lighting is a big challenge for Goodmans because of their showroom and design needs. Recommendations were provided for energy efficient upgrades to existing lighting that will save an additional $2,000 a year.

This form of voluntary energy efficiency retrofits also generates greenhouse gas emissions reductions. The key to using the City's Green Business Certification program to deliver additional greenhouse gas savings is to increasingly quantify pre- and post-program energy use so that emissions reductions can become transparent as well as useful for promoting higher levels of success by other participants in the program.

Status Quo / Business as Usual:

EPA is now largely phasing out its successful Climate Leaders program in favor of State, local and NGO leadership in voluntary greenhouse gas reduction. Absent any additional programs emerging in the Tucson area, the City's Green Business Certification (GBC) program remains the only existing mechanism for working with the private sector to achieve voluntary energy savings and associated GHG emissions reductions.

The existing GBC program has had a few early successes but has not yet been mainstreamed into the larger Tucson business community.

Description of Measure and Implementation Scenario:

This measure proposes that the City team with the business sector to develop and implement a greenhouse gas reduction challenge program for Tucson businesses.

Partners could include TEP and Southwest Gas, along with organizations such as the Southern Arizona Green Chamber of Commerce (SAGCC)[2], formed in early 2010, and other NGOs supportive of an enhanced level of climate mitigation, energy and water savings, and overall resource efficiency that would make Tucson businesses more competitive and keep more money in the local economy. The SAGCC has already established a Level Two membership that includes participation in the City's Green Business Certification Program.

We recommend that the new program challenge participating businesses to commit to continuous quantifiable improvement in reducing their energy and water use and reducing their waste generated. Benchmarking will be important at the outset to allow a "before and after" snapshot to be developed for each participating business and to publicly demonstrate the successes being achieved.

Businesses should consider entering their energy use data into EPA's Portfolio Manager energy data accounting system and this could even be made a requirement not only for participation in the challenge program but for all businesses as a condition of business license renewal.

Participation rate projections for voluntary programs, particularly new ones, is often highly conjectural. However, it seems reasonable to aim for a participation level that at a minimum includes some or all of the over 200 members of the Southern Arizona Green Chamber of Commerce.

These businesses have already demonstrated their commitment to enhanced environmental performance and represent a favorable initial audience for a community-wide corporate climate challenge. Since late October 2010, almost 30 new members have joined the SAGCOC.

If 200 participating members of the SAGCC are encouraged to join in a corporate climate challenge, either through a new, independent target-setting group or through an enhancement to the SAGCC's three levels of membership (already featuring a commitment to the City's Green Business Certification program), significant energy and greenhouse gas emissions could be realized.

Without knowing the annual energy consumption reflected in the operations of these 200 participating SAGCC members, it is difficult to project potential energy, cost and emissions savings. As a result, we recommend that a challenge program begin by challenging participants to benchmark and then reduce energy and water consumption by 10% after three years and 50% by 2020.

Energy use by size of business will vary greatly of course. For the purposes of showing the potential of a voluntary corporate climate challenge program, we assume an average annual electricity consumption of 130,000 kWh or about 10,800 kWh/month for a combination of 200 small, medium and large businesses. Some businesses will be responsible for multiples of this number while other, smaller firms may be responsible for only a fraction of the average number.

Has the Measure been implemented elsewhere and with what results:

The **City of Ft. Collins CO** represents one of many communities with successful voluntary greenhouse gas reduction programs for business. With 170 companies involved at the time, 2007 greenhouse gas emission reductions total 82,000 tons CO2e.

There was an additional 3 billion gallons of water conserved through voluntary measures. Participants in the Ft. Collins "Climate Wise" program saved 200 million kWh of electricity and 4.2 million therms of natural gas between 2000 and 2007.

Energy/Emission analysis:

As stated above, without knowing the annual energy consumption reflected in the operations of these 200 participating SAGCC members, it is difficult to project potential energy, cost and emissions savings.

As a result, we recommend that a challenge program begin by challenging participants to benchmark and then reduce energy and water consumption by 10% after three years and 50% after eight years.

The challenge would focus on GHG reductions such that reductions of GHGs by any means, including vehicle fuels and natural gas, would be credited.

Energy use by size and nature of business will greatly vary. For the purposes of showing the potential of a voluntary corporate climate challenge program, we assume that only electricity would be saved, and savings would grow each year a business is enrolled into the program proportionate to its investment in energy savings.

This means a business invests $1,733/yr (6.7% of its total investment of $26,000 over eight years) each of the first three years in the program, achieving 3.3% more energy savings from their baseline year (year prior to enrollment).

After three years, the business would increase its annual investment to $4,160/yr for the remaining five years of its eight-year commitment (16% of its total investment of $26,000).

Some businesses will be responsible for multiples of this number while other, smaller firms may be responsible for only a fraction of the average number.

We assume that the average business participant has an average annual electricity consumption of 130,000 kWh/yr, and that 50 new businesses will be enrolled in the program per year from 2012-2019, totaling 400 by end of 2019.

We assume the participating businesses make an eight-year commitment to reduce GHGs 50%, and that the life of the investments is 10 years. The GHG savings from this program would be 13,953 tCO_2e in 2020. From 2012-2020 business participants will have saved 47,165 tCO_2e; over the 10-year lifetime of their investments they will save 235,822 tCO_2e.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	13,953 tCO_2e

Economic analysis:

Measure Costs

Costs associated with achieving the energy reduction targets established above would vary from business to business depending on

1) Factors unique to the type of business activities conducted (service, manufacturing, warehousing, etc.);

2) The condition and existing energy efficiency of business spaces;

3) The availability of best practice technologies to respond to high-energy consumptive practices from business to business;

4) Access to capital; and

5) Other factors including employee incentives, customer pressure, investor interest, etc.

An aggressive corporate climate challenge program will require an investment in human resources necessary to manage a growing and versatile business client base, establish metrics, collect and report savings data, direct businesses to available resources (funding and technical), and promote the program.

We believe this would require 3 FTE and an operations budget of $100,000 year at the outset, growing to an operations budget $250,000 a year by 2020 to manage 400 businesses.

At the assumed $100,000/yr per FTE, we project the investment by the City (or a non-profit using a diverse set of resources including City funds) to be $400,000 per year from 2012-2015, jumping to $500,000 per year 2016 through 2019.

Examples discussed throughout this report show that huge opportunity exists for saving energy at a high return on investment if capital is available. This analysis therefore assumes that the participating businesses will save energy costs at a ratio of $4 saved per $1 invested. This ratio reflects the fact that huge savings can typically be achieved by behavior adjustments that don't require capital investment.

Using the average projected electricity rate for commercial accounts of $0.10/kWh during the decade, and a (conservative) average life of ten years for the efficiency investments, this ratio means a business that invested $26,000 in 2012 to achieve the average 130,000 kWh/yr. savings for ten years would achieve electricity savings of ~$129,000, and a net savings of ~$103,000.

This analysis assumes that average business investment costs would remain stable because of the recent history of energy efficiency investments declining in real dollars with technological improvements.

Total business investment for 400 businesses is therefore projected at 400 X 26,000 = $10.4 million.

The measure's total investment is the business investment of $10.4 million plus administration costs of $3.6 million = $14 million over eight years.

Measure Savings

From 2012 through 2020, businesses are projected to save a total of $5.37 million. Over the ten-year life of the investments, total savings is projected at $31.1 million.

Net Economic Impact

From 2012 through 2020, the program will cost the City $3.6 million and businesses will not have yet recouped their energy saving investments such that 400 businesses will have a net cost ~$0.8 million:

Measure Costs:	$ 9.75 million
Measure Savings, lifetime:	$ 5.37 million
Net cost:	$ (4.38 million)

Over the 10 year lifetime of the investments, however, business savings are projected to be $31.1 million against total business investments and City costs of ~14.0 million for a net savings of $17.1 million

Dollar savings per saved tCO_2e:

In 2020: $32

2012 through 2020: ($93)

Lifetime of investments: $72

The economic impact of the lifetime savings of $17.1 million is estimated using the multiplier of 1.5 on energy savings: $25.63 million.

Co-benefits:

Businesses voluntarily taking action to become more energy and resource efficient clearly gain a competitive advantage in the marketplace as overall costs of operation decline. Additionally, there is often an enhanced public image value for such businesses that translates into increased revenues from customers with shared values in the areas of energy savings, emissions reduction, and overall resources efficiency.

Equitability:

Voluntary programs are neutral from an equitability standpoint.

Potential unintended consequences:

None anticipated.

Endnotes

[1] USEPA News Release. September 15, 2010, at: http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/dd1397789177301d8525779f005c7d9e!OpenDocument.

[2] Southern Arizona Green Chamber of Commerce, at: http://www.sagcc.org/.

Measure: Appliance Efficiency Initiative (E13)

In cooperation with existing and future appliance efficiency rebate, education and energy efficiency awareness efforts, the City should actively promote the economic benefits of consumer upgrades to energy efficient appliances, including heating, ventilating, air conditioning, water heaters, and other appliances.

In conjunction with manufacturer labeling (i.e. Energy Star) the measured savings from recent Federal and utility sponsored appliance rebate programs in Arizona demonstrate the cost, energy and greenhouse gas emissions reduction potential of appliance replacements.

Emission reduction potential by 2020:	11,428 tCO_2e / yr.
Percentage of goal (2012):	0.06%
Percentage of goal (2020):	0.5%
Total annual average implementation costs:	$413,000
Entity that bears the costs of implementation:	City of Tucson unless fees collected to fund the rebates and program administration
Cost/Savings per tCO_2e 2011-2020:	Savings $42 / tCO_2e
Net annual savings average 2011-2020:	$258,467 / yr.
Entity that realizes the financial return:	Homeowners
Equitability (progressive/regressive, income/revenue neutral, etc):	Absent a subsidy for appliance purchases, replacements will likely be made by those homeowners with the financial ability to upgrade.
Potential unintended consequences:	Waste management issues as well as potential life-cycle environmental impacts arising from extraction and manufacturing.

Background information:

Advances in appliance technology to achieve national energy efficiency targets are resulting in a new generation of most appliances. However, due to the ten-year and sometimes longer life span of existing appliances, homeowners may go several years before feeling an opportunity to upgrade or simply replace their current models.

Programs have been designed and implemented at all levels of government to encourage the replacement of existing appliances with more energy efficient models. Results from these programs are beginning to be reported.

The Department of Energy reported preliminary findings in September of 2010 of the first nationwide appliance rebate program funded under the American Recovery and Reinvestment Act (ARRA).[1] Through June 30, 2010, DOE paid out a total of 689,000 rebates nationwide at a cost of $98 million (an average of $142 per rebate).

Actual energy savings based on products rebated totaled 83,665,176 kWh. Total actual dollar savings came to $27,525,678. There were also considerable water savings being realized as the result of the appliance rebate programs.

By mid-2011 more extensive data should be available from both the ongoing Tucson Electric Power HVAC rebate program and the 2010 State Appliance Rebate program, supported under the national program mentioned above.

Status Quo / Business as Usual:

In the absence of a steady promotional effort aimed at replacing energy-inefficient appliances with newer, more efficient models, consumers will continue receiving mixed signals as to the value of such upgrades. At best, conversion to more energy efficient models will not occur until appliances break or until new labeling standards result in only energy efficient models being available.

Consumers often have a difficult time reconciling a higher first cost for an energy efficient appliance and would benefit from more consistent, easy-to-understand success stories as to life-cycle cost and energy savings advantages of higher first-cost appliances. Coupled with even small rebates, this information often spurs consumer purchasing of energy efficient appliances, particularly in an era of rising energy costs.

Description of Measure and Implementation Scenario:

The City is encouraged to cooperate with other levels of government, Tucson Electric Power, and appliance manufacturers/retailers to conduct a widespread promotion campaign encouraging Tucson households to switch to more energy (and often) water efficient appliances.

No financial incentives are proposed under this initiative though experience from government and utility programs show a high consumer interest in appliance rebates. The campaign should provide easy-to-understand information on cost savings likely as well as references to resources that may be available in the way of rebates, tax credits, or other incentives.

The campaign should also have a target goal of 10,000 appliance replacements over the decade, with 1,00 replacements being achieved each year through 2020. The campaign should be designed to measure and communicate progress towards this goal in ways that keep household interest high and momentum going. An important selling point to the campaign will be its emphasis on cost savings to households that frees up utility expenses for other family needs.

The City's role in the initiative would be carried out by an existing and perhaps re-directed FTE who would also have responsibility for other collaborative and promotional efforts (i.e. Expanded Residential Energy Efficiency) in support of the overall climate action plan implementation. The City's FTE cost was estimated at $45,000/year in the Expanded Residential Energy Efficiency measure and would not need to be duplicated.

Has the Measure been implemented elsewhere and with what results:

The City of Lauderhill together with the State of Florida created a financial assistance program for residents to purchase appliances that consume less energy. Lauderhill's program, funded by an Energy Efficiency and Conservation Block grant to the city, provides interest free loans to city residents to purchase Energy Star washers, dishwashers, refrigerators, freezers, solar water heaters, tankless water heaters, and air conditioners with a 16 SEER rating or higher.

The loans can only be used in the residents primary home. Loans were secured to the appliances purchased, and linked to the borrowers checking or savings account to provide for automatic monthly payments to the city. Payments are for 12 or 24 months, with the minimum loan of $400 and the maximum loan of $2000.[2]

The City of St. George Utah's Energy Services Department offers rebates for Energy Star eligible appliances used in primary residences. Rebates are available for clothes washers, electric heat pump water heaters, electric hot water heaters and refrigerators. Equipment must meet program standards specified on the program application. Rebates apply to only primary residences and are only available to residents living in SGESD service territory.

Rebates will be paid in the form of a credit to the customer electrical utility account. Include a paid receipt with qualifying purchase highlighted, then sign and mail application to the contact address above. Refrigerator rebates are available to all SGESD customers. Hot water heater rebates are only available to "all electric homes". Rebates are paid in the form of a credit issued on the electrical account.

In 2010, the State of Arizona implemented a mail-in rebate program using $6,237,000 in American Recovery and Reinvestment Act (ARRA) funds to help residents replace older, inefficient appliances with ENERGY STAR® qualified appliances. Eligible products included: clothes washers, dishwashers, gas storage water heaters, gas tankless water heaters, electric heat pump water heaters, refrigerators, freezers, room air conditioners, and solar water heaters (both electric and gas back-up).

Rebates varied based on the appliances' efficiency levels. Consumers were also required to self-certify the replacement of an old appliance.[3] The program had one key objective: help individual consumers replace old and inefficient appliances with new appliances that are generally 15-50% more energy efficient.[4]

In Arizona, the ARRA funds rebates applied to clothes washers ($3,151,000) will result in energy and water savings of $4,677,000 over the life of the clothes washers purchased.[5]

As of December 31, 2010, Arizona had provided more than 26,000 rebates ranging from $75 for room air conditioners to $500 for solar water heaters. The program prompted the purchase of more than 24,000 ENERGY STAR® qualified appliances, bringing in some $21 million in sales.[6]

No estimated energy efficiency savings data from this program will be available until March 2011 as final calculations and validations of rebates usage are still underway. Results will be posted on the State Commerce Authority webpage.[7]

Also in 2010, Tucson Electric Power Company (TEP) and Unisource Energy (UES) customers were eligible for rebates of up to $250 for installing a new high efficiency air conditioning unit or heat pump (minimum of 14 SEER).[8] TEP is unable yet to disclose the number of rebates distributed or the expected energy savings anticipated as a result of this program.[9]

Energy/Emission analysis:

Absent any kind of directed funding available (e.g. rebates, credits, or new appliance purchases) for specific kinds of appliances it is difficult to forecast the range or number of existing home appliances that might be replaced in a voluntary, information-based campaign.

However, multiple experiences with forms of community-based social marketing has shown that awareness and peer behavior are often enough to stimulate behavior change in others. We project that a minimum of 10% of Tucson homeowners and landlord/tenants would be influenced by a successful energy efficient appliance promotion campaign to the point of replacing one energy inefficient appliance in their home with one carrying an Energy Star label.

To illustrate the energy and emissions savings potential of this response, we use the case of an Energy Star air conditioner delivering approximately 1,260 kWh energy savings per year (note that for Tucson's climate, EPA predicts that an Energy Star air conditioner will save 1,673 kWh/yr.).[10]

As air conditioning is estimated to be 75% of the energy use of the four major home appliances in the Tucson area (dishwasher, clothes washes, refrigerator and central air conditioner), and central air conditioning units have the biggest difference (and therefore the most initial purchase cost barrier) between Energy Star and inefficient units, this analysis will henceforth assume that the rebates are used for air conditioning replacements.

If ten percent of Tucson homeowners (who have not already purchased an Energy Star air conditioner) were to participate, a total of 10,000 energy efficient appliances might be replaced with less-efficient units. At 1,260 kWh savings annually per unit, the savings for 10,000 replacement air conditioners would reach 12,600,000 kWh/yr by 2020.

Greenhouse gas emissions savings from this activity would total 1.1 tCO_2e per year per unit, based on 2 pounds of GHG emissions by TEP for each kWh.

On the assumption that 10,000 air conditioning unit replacements occurred because of the initiative, total GHG savings in 2020 would amount to 11,428 tons. Accumulative savings from 2011-2020 would be 61,714 tCO_2e. Over the lifetime of the appliances, the accumulative savings would be 113,143 tCO_2e.

Climate Change Impact Summary

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	11,428 tCO_2e

Economic analysis:

There are two scenarios for an existing air conditioning unit to be replaced: a window unit, or a central unit. As the EPA reports that the difference between a central unit that is inefficient and an Energy Star unit is ~$500, and the difference between window units ~$100, this analysis assumes an average City rebate of $388 based upon the following:

Savings resulting from 1,000 efficient air conditioning units per year is estimated at 325 kWh per house per $100 of price difference between inefficient and Energy Star units (based on the ~$500 difference and 1,673 kWh/yr difference between central air conditioners.[11]

The annual savings of 1,142 tCO2e is based on 1000 units each saving 1,260 kWh, which translates to a rebate requirement of (1260/325 * 100) = $388 rebate per unit.

Measure Costs

Measure costs are 10,000 rebates averaging $388 each = $3,880,000. A 0.25 FTE at $100,000/yr/FTE is assumed to be required to administer the program, bringing total average annual costs to $413,000 over ten years 2011-2020, or $4,130,000 for the 2011-2020 duration of the measure.

Measure Savings

Each unit saves 1260 kWh/yr, so one year's program of 1000 rebates saves 1,260,000 kWh at the price per kWh of that year. We assume that residential kWh prices are $0.08/kWh in 2011 and increase at 2.4%/yr.

The consumer savings from new AC units purchased in 2011 is estimated at $100,800. Savings from units purchased in 2020 is estimated at $124,785.

We assume the appliance units have a 10-year lifetime. By 2020, the annual savings to consumers since 2011 totals $1.25 million from the 10,000 units purchased.

A unit purchased in 2011 will save its owner ~$1,124 over its ten-year lifetime. A unit purchased in 2020 will save its owner ~$1,425 over its lifetime. The average unit purchased during the program will save ~$1,275.

This analysis assumes that the City's $388 rebate (using AC units as the example) for the higher priced efficient appliances is all that is required for consumers to purchase them without additional expenses.

Net Economic Impact

By 2020:

Measure Costs:	$ 4,130,000
Measure Savings:	$ 6,301,000
Net Savings:	$ 2,584,670

Lifetime of the Appliances:

Measure Costs:	$ 4,130,000
Measure Savings:	$12,435,648
Net Savings:	$ 8,718,648

The net savings achieved per tCO2e saved:

In 2020:	$73
2011-2020:	$42
Lifetime of the appliances:	$77

The net economic impact of the measure, based on a 1.5 multiplier of energy savings achieved, is projected to be:

In 2020:	$1.87 million
2011-2020:	$3.88 million
Lifetime of the appliances:	$13.1 million

Co-benefits:

More energy efficient appliances result in life-cycle cost-savings to homeowners and potentially lower energy bills over time as utility power plant capacity additions are delayed or cancelled. Also, new appliances should perform more efficiently in general thus delivering more of the services they were created and paid for originally.

Equitability:

Most existing and earlier appliance rebate programs established income thresholds intended to steer rebates towards households most likely to benefit from reduced utility bills. These programs were progressive in nature depending on the structure of their income or other thresholds.

A more general outreach and promotion campaign, absent financial incentives, would likely be first taken advantage of by those able to trade up in their use of appliances, followed by those who are at or near the time when appliance replacements were necessary because of age or performance issues. There is nothing inherently inequitable about the proposal however.

Potential unintended consequences:

A wholesale appliance replacement program on the scale of 10,000 units would generate an equal number of units requiring safe end-of-use management (recycling or disposal).

In addition, the life cycle materials (and possibly energy) costs of an appliance that is more efficient to operate may have environmental consequences at the point of manufacture or materials extraction prior to manufacture of the appliance and its subcomponents. More information may be useful on the life-cycle energy and environmental impacts of Energy Star appliances.

Endnotes

[1] USDOE, "State Energy Efficient Appliance Replacement Program: An Assessment." September 30, 2010, at: http://www.naseo.org/events/annual/2010/presentations/Macrae.pdf.

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[9] Communication with Vicki Boes, TEP, January 5, 2011.

[10] Spreadsheet with assumptions are downloaded from: http://www.energystar.gov/index.cfm?c=products.pr_find_es_products.

[11] Spreadsheet with assumptions are downloaded from: http://www.energystar.gov/index.cfm?c=products.pr_find_es_products.

Measure: City of Tucson Energy/Water Performance Contracting (E12)

When capital funds are unavailable for energy or water saving investments with a strong positive rate of return, energy service companies are able to provide the financing through contract mechanisms that can guarantee annual savings. The contracts frequently include an extensive audit to define the investments with the highest returns.

This measure calls for the City of Tucson and other organizations in Tucson with sufficiently large energy and water use to justify an EPC to maximize their use of EPCs to maximize their energy and water efficiency and minimize GHG emissions.

Emission reduction potential by 2020:	10,471 tCO_2e/yr.
Percentage of goal (2012):	0.14%
Percentage of goal (2020):	0.46%
Total annual average implementation costs 2013-2020:	$384,500/yr. paid to ESCO
Entity that bears the costs of implementation:	ESCO finances improvements; City of Tucson pays ESCO to achieve savings
Cost/Savings per tCO_2e:	Savings in 2020 of $193/tCO2e
Net annual savings in 2020:	$2.023 million
Entity that realizes the financial return:	City of Tucson and ESCO
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	City revenue loss compared to city self-financing the efficiency investments

Background information:

While energy/water *conservation* can be done without capital investments (e.g. turning lights off), energy/water *efficiency/productivity* frequently requires a capital investment, typically from borrowed funds unless a one-time-only grant (e.g. ARRA) or private sector equity injection is available.

Energy Performance Contracting (EPC) is a well-established system for maximizing capital funds for energy/water investments at minimal cost or reduced risk to the borrower since the capital is provided by a third party (typically a for-profit company) that will also assume most of the risk of the project's success at reducing energy/water use. The EPC company, generally called an Energy Service Company (ESCO), retains a negotiated share of the utility bill savings from the energy/water efficiency investment to generate its profits.

The ESCO client, in this case the City of Tucson and other Tucson organizations with a large energy/water footprint, avoids the need to borrow energy efficiency investment funds and avoids the risks associated with the investments achieving their projected savings. A typical commitment for the client would be to pay its existing levels of utility bills (with a built-in rate escalator) for a period of time during which the ESCO investment is paid off, after which the client enjoys all of the cost savings.

EPC projects typically begin with an audit of the potential energy/water savings that will be cost-effective over the lifetime of the investment and total costs of capital for the project, after which EPC negotiations occur concerning timing of the investments, risks assumed by the building owners and the ESCO, and other financial details.

Both energy and water savings investments are eligible, and both have GHG reduction potential. Water usage requires energy to treat and distribute water and handle wastewater, causing an indirect source of GHG emissions.[1] Heating water requires direct (natural gas) or indirect (electricity) GHG emissions. Likewise, generation of energy, particularly electricity generated by coal- or nuclear-thermal powerplants, consumes large amounts of water. In other words, any energy saved also saves water, and any water saved also saves energy and GHGs.

A preliminary analysis of the Tucson Convention Center (TCC) identified potential savings. Retrofits of lighting systems, air circulation and water fixtures were estimated to annually save 7.6 million kWh, 150,000 therms of natural gas and 936,000 gallons of water. Though every building is different, similar savings per interior square foot are likely to be possible.

Status Quo / Business as Usual:

For various reasons, it is very difficult for governments or businesses to dedicate the capital needed to achieve maximum energy and water efficiency at any one time. The potential of addressing potential investments with a strong rate of financial return on a piecemeal basis can cost far more than addressing all the opportunities at once.

The business as usual scenario, particularly in the difficult economic times of 2011, is likely to be a very piecemeal approach to energy and water conservation investments. This analysis assumes that only 5% of the investments needed to maximize energy and water conservation would be accomplished each year, compared to the 100% that could be accomplished in 2011 through an ESCO arrangement.

For example, a US Federal facility was found to require ~$9 million of investment for high rate of return energy and water conservation retrofits. If $500,000 were obtained every year for 18 years, the additional energy and water costs incurred would cost ~$2 million more than an ESCO contract that provided ~$800,000/year guaranteed savings from existing utility bills.[2]

If such opportunities were not a big win/win for both parties, the ESCO industry would not be growing and thriving.

Description of Measure and Implementation Scenario:

The City of Tucson would maximize the energy and water efficiency of its buildings by pursuing EPC agreements.

An option for this measure is for the City of Tucson to develop incentives for other public / private sector buildings to use EPCs, if incentives are shown to be necessary through further market analysis.

The City has two fundamental options to maximize the energy/water efficiency of its buildings: self-finance or use the EPC process to finance through an ESCO. This report addresses the latter strategy, although it is likely that if the City were to self-finance the improvements, it would reap more of the financial rewards.

ESCO contracts are typically executed for several buildings with similar investment needs. The most likely implementation scenario is that in partnership with ESCOs, the City will identify several bundles of buildings for EPC contracts.

Has the Measure been implemented elsewhere and with what results:

Houston TX: The City of Houston TX has recently used EPC contracts to address energy efficiency in its buildings through the Clinton Climate Initiative. The first contract in 2009 concerned seven buildings where an investment of $9.6 million by Schneider Electric will provide the City with annual savings of $720,000.

In Phase 2, announced April 2010, Schneider Electric's investment of $23 million in 19 facilities is expected to result in City savings of $1.8 million annually for 15 years, after which savings are fully captured by the City. The Phase 2 project includes 1.65 million square feet, including city hall.[3]

Aurora CO: The City of Aurora CO has used an EPC contract with Johnson Controls to reduce its city center utility costs ~20% through a $4 million investment. The company has also assisted the City in maximizing the energy savings potential of the existing systems at the Center, saving ~$15,000/year. The City Council voted in 2007 to require LEED Gold achievement by all new construction and major building renovation projects in order to maximize energy and water cost savings and employee comfort.[4]

Charleston SC: The City of Charleston's sustainability initiative resulted in an EPC with Johnson Controls that will save $18.5 million over 15 years through water, energy and operational savings. The project is estimated to reduce water use by 40% and reduce CO2 emissions by 10,000 tons per year.[5]

Energy/Emission analysis:

This analysis assumes that all City buildings will be subject to an EPC contract that will improve energy efficiency by 25%, with one-quarter of buildings included in a bundle each year for four years starting 2012 (allowing 2011 for EPC contracting).

By this measure, City facilities will on average be 25% less carbon intensive by the beginning of 2016, allowing one year for each phase of improvements to be completed (it is possible that the improvements could be completed faster – which should be done by the City if feasible).

Water use by the City is not a significant source of GHGs and so it not addressed, though the City's water operations were found to be far more important in the City's GHG footprint at 114,118 tCO_2e – meaning that GHGs associated with water deserve their own reduction initiative.

The City's buildings inventory includes ~6.18 million square feet of interior space. Pima County manages an additional ~243,000 square feet located on City property, but this measure only analyzes City operations.

The PAG 2010 inventory reports that in 2008, City facilities emitted 41,884 tCO_2e. This analysis assumes that the 41,884 is reduced 25% to 31,413. The emission savings in 2020 are the

Climate Change Impact Summary in tCO_2e.

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	End of 2012: 2617; in 2020: 10471

Economic analysis:

Measure Costs

We assume that the ESCO contractor will keep 20% of the savings achieved by the City. By the end of 2020, the ESCO will have earned $3.07 million.

Measure Savings

The PAG GHG inventory shows the City's facility-related energy use in 2008 to be 152,512 million BTUs from electricity and 64,713 from natural gas usage.

This analysis assumes that electricity and natural gas rates will increase 2.4% per year, though the US Energy Information Administration predicts natural gas prices will remain stable.[6]

At the average price of natural gas sold to industrial customers in Arizona of $7.79 per thousand cubic feet in 2010,[7] City of Tucson's annual natural gas bill is estimated at ~ $5.3 million in 2013.

We assume that the average price paid by the City of Tucson is presently $0.07/kWh. City of Tucson's electricity bill is estimated at $3.28 million in 2013.

The City's savings in 2020 is estimated at $2.02 million.

City cost savings 2013 through 2020 are estimated at $12.3 million. If the ESCO efficiency investments have a 20 year lifetime, the City's savings will add up to ~$52.13 million by 2036.

Net Economic Impact

Measure Costs 2011-2020: $3.07 million

Measure Savings 2011-2020: $12.3 million
Net Savings 2011-2020: $9.23 million

Savings per tCO2e saved in 2020: $193
Savings per tCO2e saved 2013-2020: $136

We apply the 1.5 multiplier impact to these savings because it is likely that the savings, whether they accrue to citizens in the form of lower taxes, or to other City uses will have a higher economic multiplier than the expenditures on energy. The net impact of the 2011-2020 savings is projected $13.8 million.

<u>Co-benefits:</u>

Reduced pressures on City budgets for utility bills, which could lead to lower taxes or the ability to fund other citizen needs.

A secondary benefit, which has accrued to some organizations that mount energy efficiency strategies, is that City employees become more aware and competent at spotting energy and water efficiency opportunities, which could increase savings from this measure.

<u>Equitability:</u>

Neutral – there are no significant consequences for the financial well-being of Tucson citizens, aside from saved costs by City government.

<u>Potential unintended consequences:</u>

If the City self-funded the efficiency improvements, it might be able to keep more of the financial savings – depending on interest rates and other administrative costs of the self-funding process.

Endnotes

[1] For example, Colorado Springs Utilities of Colorado Springs, Colorado estimated that about 5,200 kilowatt hours are required to treat, pump and wastewater treat one million gallons of municipal water. Source: Steve Doty, Colorado Springs Utilities, email correspondence.

[2] Personal experience of Christopher Juniper, Westmoreland Associates, 2009.

[3] Schneider Electric press release, "City of Houston Commits to Sustainable Future, Kicks Off $23 million Energy Efficiency Project with Schneider Electric," April 22, 2010, at: Schneider-electric.us.

[4] Johnson Controls, City of Aurora CO Case Study, at: www.johnsoncontrols.com.

[5] Jeffrey Van Ess and Tricia Kuse, Johnson Controls White Paper, "Savings Multiplied: Conserving Water and Energy to Maximize Efficiency and Reduce Emissions," 2010, at: www.johnsoncontrols.com.

[6] US Department of Energy, Energy Information Administration, "Outlook 2010 with Predictions to 2035," 2010, available at www.eia.gov.

[7] US Energy Information Administration, Natural Gas Monthly, December 2010, at: http://www.eia.doe.gov/natural_gas/data_publications/natural_gas_monthly/ngm.html.

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Measure: Community Climate Challenge (E14 and E23-Energy Efficiency Education Program)

Design and implement a community-wide climate challenge. Primarily, implementation of this measure consists of a website where households can pledge a reduction, estimate their impact, and learn ways to promote energy efficiency and conserve energy. The costs involved are a result of the website, personnel to run the campaign, and advertising.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	7,884 tCO_2e
Percentage of goal (2012):	0.41%
Percentage of goal (2020):	0.35%
Total annual average implementation costs:	$33,311
Entity that bears the costs of implementation:	Government
Cost/Savings per tCO_2e:	$4.23 / tCO_2e
Net annual savings:	$16.35 / home / year
Entity that realizes the financial return:	House
Equitability (progressive/regressive, income/revenue neutral, etc):	Progressive; low income neighborhoods could be targeted
Potential unintended consequences:	See below

Background information:

A Community Climate Challenge ("Challenge" hereafter) is a program primarily aimed at community-wide educational outreach campaign and strategic community partnerships that encourage participants to voluntarily reduce their greenhouse gas (GHG) emissions. According to Denver's Mayor, John Hickenlooper: [1]

> "We've had a lot of success with our Residential Climate Challenge program, … Because energy conservation is best met by a change in individuals' behavior, helping people learn how to make change in their home is proving critical to our carbon reduction goals."

Challenge programs are believed to be an important part of larger, community-wide sustainability frameworks, while being synergistic with other short- to medium-term climate strategies (eg, recycling, home/business energy audits, smart meter implementation, energy efficiency programs). However, these synergies result in difficulties relative to GHG saving and economic cost disaggregation (discussed below).

In some programs, residential and corporate community-members are engaged to contribute to overall reductions of community GHG emissions by pledging to reduce their emissions. Challenges in many communities are supported by a website wherein pledges can be made, links are provided for resources and information, and individual/household emissions can be calculated via a 'carbon calculator'. [2]

Participating members usually bear the cost of any energy efficiency upgrades (that may be offset partially or wholly) by local incentives. Costs to the implementing body are usually minimal including staff time and a website.

A Challenge has the ability to enhance other mitigation initiatives included in this report. Programs in cities like Denver and Ft. Collins, Colorado and Burlington, Vermont have implemented a variety of Challenges with different expectations and varying levels of confidence in participation. Applicable GHG abatement and economic assumptions will be used in this analysis.

Business as Usual:

Absent a community climate challenge, households will miss out on some energy reduction measures and behavior changes that result in energy conservation and energy efficiency.

Description of Measure and Implementation Scenario:

Incorporation of a residential Challenge into a broader climate change framework could help support other related initiatives while providing some level of behavioral change.[3]

This measure consists of a residential educational campaign to engage community members to reduce their household emissions and water consumption. Incorporation of water in the challenge will not result in material GHG emission reductions from decreased energy usage by Tucson Water although such an addition is consistent with regional adaptation strategies.

The carbon analysis assumes that a Tucson Residential Climate Challenge would be partially modeled after the Fort Collins projections. Current total emissions in Ft. Collins are 2.t $MtCO_2e$ (2009), with residential comprising 22% of the total (ie, 497,640 tCO_2e- assumed to be residential electricity only).

Has the Measure been implemented elsewhere and with what results?:

Many US cities have incorporated some form of Challenge into their larger climate planning frameworks. However, the programs are not necessarily comparable. Some programs simply ask for a pledge and provide some resources and links to information. Other programs include a variety of other community-relevant climate change measures. Below, the Challenges for Burlington, Vermont, Ft. Collins, Colorado and Denver, Colorado are described below:

Ft. Collins Community Climate Challenge:[4]

The program is "*for the residential sector, focusing on an educational campaign to promote actions with a goal of reducing 1% of per capita GHG emissions. A key component would be youth- focused programs (in-school programs, scouts, youth groups, church groups, services groups, etc.*" They estimate a 25,000 ton reduction of CO_2e in 2012, but the program is considered to have a 90% overlap with other short-term climate strategies. The projected costs to Ft. Collins are $30,000/yr plus administrative personnel. The project is currently postponed "*until a broad interdepartmental environmental communication plan was developed*."

Denver's Residential Climate Challenge:[5]

Denver's program is more a suite of community energy efficiency and energy conservation programs aimed at household emission reductions. Their measures include a compact fluorescent lamps (CFL) program, smart meters, free energy audits, a low-income neighborhood energy conservation program, and transit marketing. Taken in concert, the projected GHG savings from these measures are close to 160,000 tCO_2e annually.

Burlington's 10% Challenge:[6]

"*The 10% Challenge is a voluntary program developed to raise public awareness about global warming and to encourage households and businesses to reduce their global warming-causing greenhouse gas (GHG) emissions by at least ten* *percent.*" The associated website offers a carbon calculator, links to resources for individuals and businesses, and a place for participants to make their pledge to reduce their GHG emissions. Given the program's structure, the initial capital costs of the program were reported to be a $12,000 capital investment in a website and $500 - $1,000 for website maintenance.

The UA Student report for this measure concentrated on extrapolations of Burlington's pledge data. The analysis herein will focus on the Ft. Collins model. It is worthwhile to note that a recent consulting report to Burlington listed such action "*will have no or little impact on the City's GHG emissions inventory, [is] not easily assessable, may be cost-prohibitive and/or impractical, and/or are not suited to near- or mid-term implementation. Though not immediately useful, [it] may provide fodder for future GHG reduction ideas and general City sustainability strategy development.*"[7]

Energy/Emission analysis:

Description	***Input***	***Notes***
Ft. Collins Inputs		
2009 GHG	2,604,559	tCO_2e
Residential %	22%	
Total Residential GHG emissions	573,003	Assumed only electricity
Housing Units (2009)	59229	http://www.fcgov.com/advanceplanning/trends.php
Population (2009)	137,200	http://www.fcgov.com/advanceplanning/trends.php
Per Captia Emissions	19.0	
Residential GHG Total per household	9.7	
Assume campaign reaches 60% of homes	35,537	
Assume 20% of 60% implement	7,107	Houses that implement
Total assumed annual reduction (excluding double counting)	2,500	tCO_2e
% reduction from Challenge	0.44%	
Reduction per house implementing	0.4	tCO_2e
% reduction per household	3.6%	
Capital costs per homes reached	$1.41	
Capital costs per tCO_2e abated	$20.00	

Tucson Analysis		
2008 GHG	7,227,674	tCO_2e
Residential Energy Use	25%	
Total Residential GHG emissions (electricity only)	1,806,919	tCO_2e
Housing Units (2008)	394,600	
Population (2006)	555,975	Derived from 2010 Inventory
Per Capita	13	Per 2010 Inventory
Residential GHG TOT per household	4.6	
Assume campaign reaches 60% of homes	236,760	
Assume 20% of 60% implement	47,352	
Assume similar home reduction to FC	7,884	tCO_2e
Reduction per house implementing	0.2	tCO_2e
% reduction per household	3.6%	
Capital costs	$333,113	Extrapolated from Ft. Collins per home cost, assumed to be over 10-years
Capital costs per tCO_2e abated in first year	$4.23	Difference is due to home efficiency in TUC v. Ft. Collins
Additional savings from incorporating water	384	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline)[8]:	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Community Climate Challenge		

Contribution of E14 Community Climate Challenge:	7,884	tCO_2e
2020 Contribution of E14 Community Climate Challenge:	0.35	%

Regarding water: given an average of 110 GPCD (residential gallons per capita per day) and an average of 1.41 people per household (derived from above), each home uses approximately 56,570 gallons per year.[9] The embedded energy in delivering a gallon of water for Tucson is 0.002475 kWh of electricity and 0.000295 gas therms.[10] 1kWh of electricity in Tucson is equal to 856g CO_2e (derived from PAG's GHG Inventory) 1 therm of gas is equal to 5470g CO_2e.[11] Therefore, one gallon has 2.35g CO_2e (elec) plus 1.61 CO_2e (therm), or a total of 3.96 gCO_2e/gal. If the Challenge produces the same 3.6% reduction in water as calculated for GHGs above, 2,037 gals/yr would be saved. Over the 47,352 homes assumed to participate, that would total 96.4M gallons and, therefore, 382 tCO_2e. Although adding the water might be advisable from an adaptation vantage, it doesn't produce substantive GHG reductions and is, therefore, left out of the final numbers.

Economic analysis:

Gains achieved from educational campaigns are hard to quantify, especially in light of no representative data. The economic analysis is based on extrapolated data from Ft. Collins' projected costs and energy savings as indicated above.

The costs are assumed to be directly proportional to the quantity of homes targeted by the educational campaign. The analysis that the campaign reaches nearly 240K homes and that 20% of those homes implement some GHG emission reductions resulting in a reduction of 7,884 tCO_2e/yr. The capital cost of the campaign is approximately $333K resulting in a cost per metric ton of CO_2e reduced of $4.23 over a 10-year life of the program.

Savings to each home is calculated to be:

0.2 tCO_2e/home x 1,000,000 g/t x (1 kWh/856 gCO_2e) x $0.07/kWh = $16.35/home/yr

Co-benefits:

Although the above GHG savings and economic analysis don't have a large impact on the City's overall goals, there are other benefits from incorporating such a Challenge into a large framework of mitigation and adaptation measures. If the measure is carried out in a similar fashion to Denver's Residential Climate Challenge, the collective net energy savings could be closer to something that they are projecting (8% towards their emission reduction target).

Furthermore, a successful educational campaign could make future initiatives more politically feasible, the implementation of such a program is equitable to all socioeconomic levels of Tucson's constituents, and integration of a water reduction challenge lends itself to regionally applicable adaptation strategies.

Equitability:

The measure is income neutral and the marketing can be directed to the neighborhoods of the COT choosing.

Potential unintended consequences:

Given public polling, some skeptical/denialist households/constituents could be vocal about their dismay over the use of public funds for such endeavors. However, such educational campaigns are crucial to turn the tide of public opinion and understanding.

NOTE on E23 Energy Efficiency Education Program:

This measure's implementation is the same as that of E14 (Community Climate Challenge) and E7 (Climate Wise). It is important during our analyses we don't allow for double counting of emission reductions. Therefore, any reductions from an energy efficiency program are accounted for under the above mention measures.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.usmayors.org/climateprotection/reports/power-of-86-million-1000thMayor.pdf.

[2] A carbon calculator helps an individual/household understand their GHG emissions.

[3] A corporate outreach campaign is under a different designation in this report- *Climate Wise*. Different municipalities either call this measure a Corporate Climate Challenge (Denver, CO), Climate Wise (Ft. Collins, CO), or Climate Partnership (Seattle, WA).

[4] Ft. Collins Climate Action Plan 2007

[5] Denver's Climate Action Plan

[6] http://www.cleanair-coolplanet.org/for_communities/PDFs/10PercentChallenge.pdf

[7] City of Burlington Climate Action Plan, 2010

[8] PAG Regional Greenhouse Gas Inventory- 2010

[9] Tucson Water- Water Plan: 2000-2050, Chapter 3

[10] ftp://www.pima.gov/wwwroot/CEDnew/includes/%255C/wwwroot/Administration/Sustainability/GHC%2520Emissions%2520Target%2520and%2520Forecast.pdf

[11] http://carbon-calc.erg.berkeley.edu/documentation/CoolClimate_TA_methods_121709.pdf

Measure: Residential Solar Street Lights (E22)

Install solar-powered LED streetlights whenever new streetlights are added to Tucson residential areas. The initial installment of 1,000 solar streetlights will be evaluated as to energy savings and used to benchmark additional solar streetlight deployment in future years.

Note: The potential savings from this measure are uncertain enough that the GHG emissions savings are not counted towards achievement of the City's 2012 and 2020 goals. The reasons are (1) solar streetlights appear to be cost-effective already in 2011, so the measure would not make a difference in whether they were purchased or not; and (2) the additional of streetlights in residential streets is optional for the City, so numbers of installations to 2020 could range from zero to thousands.

Emission reduction potential by 2020:	176 tCO_2e/yr.
Percentage of goal (2012):	0.00009%
Percentage of goal (2020):	0.008%
Total annual average implementation costs:	$0 – Solar is less expensive than alternatives in 2011
Entity that bears the costs of implementation:	City of Tucson (new residential street lights are optional)
Cost/Savings per tCO_2e in 2020 and over lifetime of solar streetlights:	Savings: $96 / tCO_2e
Net annual savings in 2020:	$16,768 / year
Entity that realizes the financial return:	City of Tucson
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	Insignificant

Note:

Net savings 2011-2020 is projected at: $84,680. Net savings over lifetime of the solar streetlights is projected at: $381,000.

Background information:

In residential areas where conventional, grid-connected electric streetlights have yet to be installed, neighborhoods in the U.S. and overseas are beginning to adopt stand-alone solar or hybrid, solar-wind powered streetlights.

These lights have first-cost, energy savings, and greenhouse gas reduction benefits apart from benefits in the way of security and better night and low-light visibility for traffic.

In a solar streetlight, a solar panel absorbs sunlight and converts it to electricity to generally to power a 60W LED pole-mounted street light. The overall streetlight system consists of a small solar panel, a 60W LED street light fixture, a battery, controller, and a pole 18-24 feet high. Exact system specifications will depend on average local solar insolation, desired working hours per day of the streetlight, and backup days of storage desired for periods of low/no sun.

One Tucson neighborhood is included among the early adopters nationwide.[1] It is currently in the design phase of a project featuring 40-50 pole-wrapped solar collectors, and a Ni-CD battery with an 11-year life span.

Status Quo / Business as Usual:

The City of Tucson currently maintains some 9,000 residential, grid-connected streetlights, some (850) with LED fixtures and the remaining 8,150 use high-pressure sodium lamps. There are more neighborhoods in the City without streetlights than there are with streetlights and the number of potential solar street lighting opportunities is in the “thousands.”[2]

The Business As Usual scenario in the short-run includes City of Tucson difficulty obtained the capital investment funds for new streetlights – making the ability to use energy-efficiency or solar-energy grants more important.

Description of Measure and Implementation Scenario:

This measure proposes the installation of solar-powered LED streetlights whenever <u>new</u> streetlights are being planned for installation in Tucson neighborhoods.

An initial analysis is provided here for 1,000 such streetlights, although the total number of potential new solar streetlights is much higher. We do not forecast when the solar lamps might be installed over the decade, but set a target of 1,000 lamps in place by 2020. We suggest this as an opportunity for funding sources such as grants, additional federal or state transportation/community development or energy programs, or utility partnerships.

Has the Measure been implemented elsewhere and with what results:

Using a combination of solar, wind and battery power, the Prentiss Creek Subdivision in Downers Grove, Illinois (a Chicago suburb) is the first residential subdivision in the United States with hybrid streetlights.[3]

The Prentiss Creek Hybrid Street Light Project includes 25 energy-efficient streetlights comprised of wind turbines, solar panels and LED lights. The system uses no electricity from the grid. The super-quiet vertical-axis turbines work in both low and high winds. The sealed batteries located at the base of the pole store up to three days worth of electricity and are good for about 10 years. A special coating on the traditional-style concrete post is graffiti-proof.

The self-contained hybrid system is designed to last for up to 100,000 hours, compared to conventional lighting systems that need to be replaced after 10,000 hours. When compared to traditional streetlights, it is estimated the hybrid system will save 500,000 kilowatts of electricity and reduce carbon dioxide emissions by nearly 350 tons over a 30-year period. Nearly half of the $282,500 project was funded by Community Development Block Grant (CDBG) Agreement from the DuPage County Neighborhood Investment Program.

The Prentiss Creek Hybrid Street Light Project took about six months to complete, requires little maintenance, saves money and reduces carbon emissions while providing much needed light to the neighborhood.

Energy/Emission analysis:

If solar LED street lights are assumed to substitute for grid-connected LED streetlights, then the energy savings per light is the 53 W of the lamp times 10 hours of daily usage incurred by an LED fixture, or 193 kWh/year. For 1,000 solar streetlights this amounts to an annual energy savings of 193,000 kWh.

If solar LED streetlights are assumed to substitute for grid-connected high-pressure sodium lamps, then the energy savings per light will be the 1.3 kWh/day usage incurred by a high-pressure sodium fixture, or 475 kWh/yr. For 1,000 solar streetlights, this amounts to an annual energy savings of 474,500 kWh/year.

Greenhouse gas emissions reductions for this example total 175 tCO2e (193,450 kWh x 2.0 pounds CO2/kWh divided by 2205 pounds/metric ton) for the avoidance of grid-connected LED electricity use.

Solar streetlamps in lieu of grid-connected HPS lamps save 475 kWh/year each. One thousand solar streetlights on-line in 2020 would thus save the City 475,000 kWh of electricity.

Greenhouse gas emissions reductions for this example total 431 tCO_2e (475,000 kWh x 2.0 divided by 2205 pounds/metric ton = 431 tCO2e. There is a range of savings, from 175 – 431 tCO_2e depending on the type of gird-connected fixture to be avoided.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	176

Economic analysis:

Measure Costs

This involves comparing the complete installed cost of a conventional street light and annual electricity consumption with the complete installed cost of a solar streetlight.

Based on information from the City Department of Transportation, the installed first cost of a new, conventional pole mounted LED or high-pressure sodium lamp is $6,000 in addition to site-specific excavation, trenching, foundation and conduit costs.[4]

Based on information from one company with a commercially available solar street lamp product, the following data are available. The company, Solar Illuminations, offers the following product:[5]

> A SL01 Solar “High Lux” Street solar-powered streetlight uses the latest LED and SMD technology. Illumination time is generally from dusk to dawn and is fully automated via a photocell (light sensor). The lamp head attaches to the support arm that, in turn, fixes to the pole. The pole has an integral base that can be bolted directly to a level, solid surface. A ground anchor kit and templates are included. A battery box is supplied to facilitate the rechargeable batteries. The 140w or 180w solar panel attaches direct to the pole and is rated for use in most applications.

This system stores reserve power to allow for up to several days of cloudy weather. The light head is fitted with either 744 Cree® LED's, 552 Cree® SMD's, 972 Cree® LED's or 720 Cree® SMDs which have a typical lifespan of approximately 100,000 hours (about 22 years).

Prices for typical systems start at $3,000. The standard, stocked product is the 552 SMD lamp with a 20' pole, which is a popular choice for most customers. Shipping costs will vary and are subject to quantity, size and weight of shipment as well as delivery address. The more powerful 972 LED sells for $4000 and provides almost 6,000 lumens. For a majority of US states, domestic shipping is typically (on average) around $500 for one street light with 20' pole and around $350 for each subsequent street light with 20' pole sent at the same time to the same address. (Retail prices for the 552 and 972 are $3500 and $5500.)

Thus, the cost of a solar streetlight (not including installation or non-retail discounts available) comes to approximately either $3500 or $5500, shipping included. Solar street lights avoid the need for trench excavation and conduits. Only a foundation for the pole is necessary.

From this analysis, the cost of hardware for a complete, pole-mounted solar street light as defined above is cost-neutral or cheaper that the cost and installation of a conventional pole and street lamp assembly, whether LED or HPS illuminated.

Measure Savings

If solar LED street lights are assumed to substitute for grid-connected LED streetlights, then the energy savings per light is the 0.53 kWh/day usage incurred by an LED fixture, or 193.5 kWh/year.

For 1,000 solar streetlights this amounts to an annual energy savings of 193,500 kWh.

If solar LED streetlights are assumed to substitute for grid-connected high-pressure sodium lamps, then the energy savings per light will be the 1.3 kWh/day usage incurred by a high-pressure sodium fixture, or 474.5 kWh/yr. For 1,000 solar streetlights, this amounts to energy avoided of 474,500 kWh/year.

Avoided electricity cost for street lighting in Tucson is presently $0.07/kWh.[6] We expect electricity rates to increase 2.4% per year to 2020, meaning that street lighting rates would be $0.087/kWh in 2020.

The analysis below assumes that 100 solar streetlights are installed each year 2011-2020 replacing LED streetlights.

Total savings in 2020: $16,768
Total savings to 2020: $84,680

Total savings over 20-year lifetime of streetlights (extending to 2040): ~$381,000

Net Economic Impact

Measure costs are projected at zero since solar street lights are less expensive to install than grid-connected LED lights. Measure net savings are therefore the total savings figures above.

The savings per tCO_2e in 2020: $96. Savings per tCO_2e from 2012-2020: $89. Savings per per tCO_2e over lifetime of the lights: $109.

Applying an economic impact multiplier of 1.5 to the energy saved, the City economy would benefit:

In 2020:	$ 25,000
By 2020:	$127,000
Lifetime of the lights:	$571,000

Co-benefits:

In addition to the economic benefits from elimination of grid-connected electricity costs, there will be savings as well from reduced maintenance on a grid-connected street-lighting project.

Other co-benefits of solar streetlights include:

1) No line voltage, trenching, or metering;
2) No power outages;
3) Able to employ battery backup for cloudy or rainy days (estimated 11-year life for the Tucson solar street light project now in design);
4) Distributed light and power - no single point of failure for enhanced security;
5) Easy to install with quick connect plugs - less than 1 hour;
6) No scheduled maintenance for up to 15 years;
7) No cost of replacing concrete, asphalt or landscaping from trenching;
8) No cost of transformers or meters to be added for electric service;
9) Possible qualification for savings from various state and federal taxes and utility incentives;
10) Controlled charging to prolong battery service life;
11) Reduced emissions of criteria air pollutants from utility electricity production;
12) Self-contained-light on/off controlled by automatic daylight sensing or hour preset, thus no running or maintenance cost; and
13) Safe 12 volt / 24 volt circuit with little to no risk of electric shock.

Equitability:

Equitability would only be impacted if the new residential streetlights were inequitably deployed not in lower income neighborhoods, or if the City's utility savings were inequitably spent. Neither of these outcomes seems likely and the savings are not a significant amount of dollars, so we believe the measure has a neutral equitability effect.

Potential unintended consequences:

Stand-alone solar streetlights will provide illumination in the event of a power failure to the installation area. This could have unintended but very positive benefits in the way of enhanced community security in what would otherwise be a blackout situation due to storm damage, heat wave-triggered grid overload, or other causes.

On the other hand should low-sun conditions persist beyond the storage capacity of the streetlight batteries the lights would no longer be operable. In Tucson, the prospects of three consecutive occluded days are remote.

Vandalism is always a possibility but is not considered unique to solar vs. conventional streetlights. Possible theft of solar panels is also possible, however a 20-foot pole elevation for a solar panel should be a significant deterrent to any but the most determined and resourceful thief.

Endnotes

[1] Conversation with Mr. Bruce Plenk, Solar Energy Manager, City of Tucson. October 15, 2010.

[2] Conversation with Mr. Ernie Encinas, Transportation Department, City of Tucson, 520-791-3154, November 15, 2010.

[3] Energy Boom. "Chicago Subdivision is First Residential Subdivision in U.S. with Hybrid Street Lights." April 7, 2010. http://energyboom.com/wind/chicago-suburb-first-residential-subdivision-us-hybrid-street-lights

[4] Encinas. Op. cit.

[5] Solar Illuminations. 2010. http://www.solarilluminations.com/acatalog/Solar_Street_Lights___Parking_Lot_Lighting.html

[6] Encinas. Op.cit.

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Local Government Policy Options

- Residential Direct Load Control (G6b)
- Expand Green Building Program / Energy Codes (G22)
- Mandatory Cool/Energy-Star Roofing (G8)
- Residential Thermal (G2d)
- Commercial PV (G2a)
- Expanded Residential Energy Efficiency (G14, G14a, G14b)
- Enhanced Direct Load Control in Commercial Buildings (G6a)
- Residential PV (G2e)
- Increased Commercial Recycling (G4, G4a, G4b)
- Time-of-Sale Residential Energy Efficiency Retrofits (G17)
- Mandatory C&D Recycling (G9)
- Non-residential Water Conservation (G23)
- Commercial Thermal (G2c)
- Solar Hot Water- Private and Public Pools (G10a/b)
- Enhanced LED Street Lighting Initiative (G3, E21, E21b)

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Measure: Residential Direct Load Control Program (G6b)

Promote the deployment by Tucson Electric Power company (TEP) of two-way residential direct load control in ~13.5% of owner-occupied single-family residences in the City per year starting in 2013 until 100% deployment is reached by the end of 2020.

Emission reduction potential by end of 2020:	~125,000 tCO_2e / yr.
Percentage of goal (2020):	5.5%
Total annual average implementation costs 2013-2020:	$7.0 million
Entity that bears the costs of implementation:	Tucson Electric Power (customers and/or shareholders)
Cost/Savings per tCO_2e in 2020:	Savings $49 / tCO_2e
Net annual savings beginning 2021:	~$15 million
Entity that realizes the financial return:	Residential electricity consumers
Equitability (progressive/regressive, income/revenue neutral, etc):	Likely positive
Potential unintended consequences:	Minimal

Note: Westmoreland Associates projects over the 20-year life of a Direct Load Control system (a smart meter or any other dynamic time-of-use system) a 10% household electricity reduction. Installation costs are projected to be (in consultation with TEP) $450 per system.

The measure's costs (to TEP or ratepayers or both) exceed its savings to homeowners by ~$3 million from 2013-2020.

Over the 20-year lifetime of the DLC systems installed in single-family homes, net savings to homeowners are projected to be ~$337 million, resulting in net savings per tCO_2e saved of $107.

Background information:

Smart meters are one form of direct load control available to electric utilities. Such meters are often all-digital devices that precisely track electric energy usage and transmit data directly to a customer's utility. Some smart meters (such as those manufactured by Itron) include advanced features that allow the meters to communicate with "smart" thermostats and appliances, allowing remote activation of electric service at the customer's convenience. The meters also measure up-to-the-minute electricity usage, and display consumption in a consumer-friendly format that allows customers to track their own usage and costs.

The new metering technology is encouraging greater energy conservation by giving electricity consumers the ability to monitor and manage better their electricity use and costs in near real-time. Various types of smart meters and other direct load control systems are available commercially and are now in use around the country.

Other load demand approaches are web-based, automatic load reading technologies that instantaneously record demand for HVAC services in a participating household and relay this information to customers via their broadband (home computer) systems. Customers can then adjust their thermostat to reduce demand for heating or cooling.

Business as Usual:

The nation is moving towards deployment of a smart grid, with increasing numbers of utility customers among the early adopters due to aggressive deployment strategies by these utilities.

In Tucson, TEP is about to pilot a "Power Partners Project involving 600 homes (and 200 small commercial customers) in an effort to determine energy savings which accrue when customers have access to real time demand and price information. The pilot will be monitored from the beginning, with at least a year's data being needed to understand the behavioral change and energy conservation that results from more instantaneous energy pricing information for air conditioning use being available to customers.[1]

TEP notes that it operates in a less-volatile grid situation than some utilities in other regions of the country, meaning it experiences less fluctuation in demand over time that might otherwise interest a utility in smoothing peaks and customers in reducing peak load pricing.[2] Partly for this reason, TEP has decided not to move to current in-the-home smart metering but rather focus on load reduction via a customer broadband interface.

Apart from this pilot program, TEP employs DemandSmart and PowerShift programs which are earlier versions of load control approaches which include time of use pricing as a key component but lack the interface with individual appliances and do not provide for two-way communication in real time between the utility and customers.

In the absence of a more dynamic direct load control approach such as that being piloted by TEP residential electricity ratepayers will likely not achieve easy energy efficiency cost savings until either rate increases occur or specific time of use pricing information systems become available.

The measure encourages the City to support TEP's Power Partners Project as it represents an opportunity for Tucson residents to be on the early edge of a national trend that is expected to become ubiquitous within the decade.

Description of Measure and Implementation Scenario:

To assist and accelerate this effort, the City could work closely with TEP to remove any code, institutional, or policy barriers now in place such that a maximum program of direct load control technology in residential homes could be realized.

This measure calls for the City to work with TEP to promote its Power Partners Project above and beyond the initial pilot stage, using savings data gleaned from the pilot period to drive expansion of the program to a wider residential audience: all owner-occupied single-family homes by 2020.

The project would aim to install systems in ~13.5% of owner-occupied single-family homes each year through 2020. This amounts to 14,471 of the owner-occupied single-family homes (107,000) projected to be in the City of Tucson in 2013.[3] By the end of 2020, over 124,500 homes will have the systems.

Has the Measure been implemented elsewhere and with what results:

Smart meter programs, a type of direct load control technology, are being implemented on a city scale worldwide. For example, beginning in late 2009 **Southern California Edison** started to install the first of 5 million smart meters in its customer service area.[4]

In **Houston, Texas**, there were 45,000 smart meters installed and operational as of August 2009, and more than 2 million are expected to be in place by the end of 2012.[5] The Texas legislature and the Public Utility Commission of Texas authorized utilities to assess Retail Electric Providers a surcharge to cover the cost of smart meters.

The surcharge, to be spread over a 12-year period, amounted to $3.24/month for each residential customer for the first 24 months, beginning in February 2009; thereafter the surcharge was reduced to $3.05/month.[6] A federal Smart Grid grant may help reduce the duration and thus expense of this surcharge.

Smart Meter programs are also in place in Ontario, Canada, and in Europe.[7]

In **Illinois**, where a program has been in place for several years, about 95% of the participants saved money (2007 data) in Commonwealth Edison's open-enrollment residential real-time pricing program, thought to be the nation's first at the time. The majority of residential customers had electricity and cost savings of between 7% and 12% according to utility reports.[8]

A recent U.K. study suggests that smart meters are capable of delivering a 10% cut in annual energy use.[9]

Energy/Emission analysis:

Average residential electricity consumption in Tucson is 11,000 kWh/year.[10] Performance data from direct load control technologies such as existing smart meter programs indicate savings in the 7-15 percent range per residence per year.[11]

The annual kWh savings assumption for this measure will be 10%, a mid-point value from the above range. Actual savings can be calculated at the end of each year using pre-program benchmark data, and exact utility billings going forward. A 10% annual reduction in home electricity consumption amounts to a savings of 1,100 kWh/year.

The measure calls for the installation of direct load control technology in ~13.3% of Tucson homes in 2013, and each year 2014-2020 to achieve a stretch goal that by end of 2020, 100% of City single-family homes have some form of dynamic, direct load control technology installed.

Westmoreland Associates believes that such levels of deployment will become increasingly more likely as energy costs rise throughout the decade, though the pace of implementation can be significantly advanced with an active education and promotion campaign as envisaged in this proposal.

The annual kWh, tCO_2e and dollar savings projections below assume that the first year a system is installed, one-half year's savings are achieved since the systems will have an average of six months of use if installed throughout the year.

Tucson Electric Power reports its most recent (2008) CO_2/kWh emission factor at ~2 pounds per kWh.[12] A reduction in individual residential electricity use of 1,100 kWh due to deployment of a Direct Load Control system would result in a GHG reduction of 1.0 tCO_2e/year (1,100 kWh/year x 2.0 pounds CO_2/kWh divided by 2,205 pounds/metric ton = 1.0 tCO_2e/year).

This analysis uses an estimate of 103,250 owner-occupied, single-family homes in the TEP service area within the Tucson city limits in 2011, and assumes that the count grows in proportion to the County's expected population growth of 1.9%/yr. Total homes with DLC by end of 2020 is 124,633.

At full deployment in 100% of Tucson single-family homes by 2021, the measure would result in electricity savings of 274 million kWh/year, resulting in GHG reductions of 124,228 tCO_2e (unless TEP's carbon emissions per kWh delivered changes by 2020 – it is likely to decrease due to Arizona's renewable portfolio standards and other TEP investments).

Assuming the direct load control systems have a 20-year life, each installation means 20 years of an 1100 kWh annual savings per household, or a 22,000 kWh and ~20 tCO_2e savings per household. The total Tucson savings over the life of the systems is about 2.5 million tCO_2e. The lifecycle savings are used in the economic impact analysis, but not the tCO_2e analysis.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2021 and beyond per year (full deployment)	125,101

Economic analysis:

Measure Costs

This analysis assumes that each direct load control system installed has a 20-year life and could cost approximately $450 to install (prices should drop once an economy of scale is reached in program implementation). The Houston Center Point Energy project cited above, using smart meters to achieve similar energy reductions, expects its residential meters to cost approximately the same.[13]

By full system deployment at the end of 2020, ~$56 million will have been invested in 124,510 homes.

Measure Benefits

At a residential electricity rate of $0.08 / kWh and rising 2.4% per year as projected by Westmoreland Associates, the installation of the systems in 13.5% of single-family homes per year starting in 2013 results in the annual savings to Tucson residents exceeding the installation costs by 2015.

By full deployment at the end of 2020, savings are projected to be ~$13.7 million, rising with electricity prices 2.4% annually to $36 million by 2032.

On a household basis, each $450 meter is projected to save ~$2,334 in electricity costs during its 20-year life, depending on when the system is installed.

Net Economic Impact

From 2013 through 2021, the savings are ~$53 million achieved for installation costs of $56 million, resulting in a net loss of ~$3 million.

Over the lifetime of the systems installed 2013-2020, the $56 million invested will save residents ~$337 million, for a net savings of ~$281 million.

The net economic impact is projected at 1.5 times the net savings of $281 million = $422 million.

The net savings per tCO2e over the lifetime of the systems is $107.

Program costs are assumed to be met by the utility, while demand reduction benefits are received by both the utility (in its capacity planning calculations and avoided power plant construction) and the homeowners (in the form of lower electricity bills).

Co-benefits:

Reduced electricity demand through use of direct load control systems such as TEP is piloting is expected to save consumers money on an annual basis. The greater that such systems drive energy conservation beyond the target reductions expected, the greater the energy cost savings to the participants and the lower the GHG emissions associated with reduced electricity demand.

Any measure that saves consumers money through lower utility costs frees capital for other potential energy efficiency measures that would be consistent with a climate adaptation strategy. More energy efficient homes become more of an asset in times of a warmer, drier climate and buffer residents against additional energy cost increases expected as a price on carbon becomes more formally established.

Equitability:

A positive equitability effect is projected. Direct load control systems will be likely to save more kWh in higher income households that have higher electricity consumption, but since the utility will install the systems at no cost to consumers (with its costs likely spread over all consumers in the rate base), the savings accruing to lower income households are likely to represent a higher percentage of disposable income, especially if electricity rates increase at a faster rate than typical lower income wage rates.

Potential unintended consequences:

Early adaptation of direct load control systems, particularly in certain smart meter programs, has created some initial consumer questions regarding billing accuracy. These were subsequently resolved along with recommendations for a more comprehensive education program to accompany meter deployment in those situations.

Privacy concerns were also initially raised in some instances, however utilities note they have been always able to track customer usage of their electricity product by time of use. The principal new feature of direct load control systems is developing consumer awareness of time-of-use price implications that are intended to influence electricity consumption behavior.

Endnotes

[1] Communication with Jeff Hunter, TEP. January 24, 2011.

[2] Communication with Denise Richerson Smith, TEP. January 24, 2011.

[3] The projection is based on 103,250 owner-occupied single-family homes in City of Tucson according to AmericanTowns.com at: http://www.americantowns.com/az/tucson-information. Westmoreland Associates projects the number to rise with the PAG projection of a regional population increase of 1.89% per year.

[4] Science and Technology. September 22, 2008. http://www.treehugger.com/files/2008/09/southern-california-edision-smart-connect-smart-meter-program.php.

[5] Center Point Energy. http://www.centerpointenergy.com/services/electricity/residential/smartmeters/.

[6] Centerpoint Energy. http://www.centerpointenergy.com/services/electricity/business/advancedmetering/faq/1997532bbadb6210VgnVCM10000026a10d0aRCRD/.

[7] IESO. http://www.ieso.ca/imoweb/siteShared/smart_meters.asp?sid=ic.

[8] Science and Technology. May 7,2008. http://www.treehugger.com/files/2008/05/smart-power-meters-real-time-pricing-energy-electricity.php.

[9] The Telegraph. November 28, 2008. http://www.telegraph.co.uk/earth/earthcomment/3534211/Smart-metering-is-essential-to-hit-2050-carbon-emission-targets.html.

[10] Communication with Denise Richerson Smith, TEP. April 2009.

[11] A Department of Energy study concluded that up to 15% could be saved by households. See: Stephen Johnson, SmartSynch, "Built-in Reminders to Conserve," Bloomberg Businessweek magazine debate "Smart Meters: Not So Brainy," March 2010, at: http://www.businessweek.com/debateroom/archives/2010/03/smart_meters_not_so_brainy.html.

[12] Regional Greenhouse Gas Inventory. PAG. October 2008.

[13] Current estimates of installed costs for smart meters range from as low as $100 to as high as $500.

Measure: Expand Green Building Program / Energy Codes (G22)

Individual components of the *City of Tucson Green Building Program* are dissected to provide the Climate Change Advisory Committee the data on the efficacy of possible building code adoptions. Ultimately, the analysis covers the emission abatement potential associated with adopting the 2012 International Energy Conservation Code (IECC). It will be shown below that many of the individual components of the *Green Building Program* are analyzed via other measures in this report.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	See individual Measures For 2012 IECC Adoption for Residential & Commercial: 114,235
Percentage of goal (2012):	NA (Code enforcement would commence January 1, 2013)
Percentage of goal (2020):	5.04%
Total annual average implementation costs:	$5.4 million over 10 years
Entity that bears the costs of implementation:	Developer/Homebuilder
Net savings per tCO_2e:	$97 / tCO_2e
Net annual savings:	$8.6 million over 27 year life of program
Entity that realizes the financial return:	Ratepayer
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	None identified

Background information:

The prologue to the City of Tucson's voluntary Green Building Rating System captures the essence of needing building codes that reflect local realities.[1] The document contains an elegant statement on the impact of the built environment, deserving to be rewritten here in full: [2]

> *"Of all human activities, the decisions we make in the design and construction of the built environment have perhaps the most significant impact on our natural surroundings, our social structure, and the long term economic viability of a community."*

In this context, "green building" encompasses a much broader scope that this lone analysis will cover. However, when taken in concert with other measures (for example, T6 Transit Oriented Growth), the City has the opportunity to head down a more sustainable path. This standalone analysis focuses on the efficacy of GHG abatement potential relative to specific "green building" program components around the areas of energy consumption.

Arizona is a home rule State meaning that all building codes must be adopted at the local municipal level. Relative to energy codes, Tucson has adopted the 2006 International Energy Conservation Code, which is average, at best, relative to the rest of the nation. [3]

Description of Measure and Implementation Scenario:

Adopt the 2012 International Energy Conservation Code (IECC) for all new commercial and residential construction. Enforcement of the code commences January 1, 2013.

Business As Usual:

The energy code for all new construction in Tucson remains as 2006 IECC. The IECC has updated the 2006 code once in 2009. Tucson did not adopt that new code despite significant community-wide savings at minimal costs to the builder and homebuyer. The 2012 code is currently still being designed. However, robust literature exists enabling the quantification of additional costs and the resulting energy savings (see below).

Has the Measure been implemented elsewhere and with what results?:

Energy code adoption varies widely within the United States. For a complete listing of the adopted codes by jurisdiction, please see http://www.energycodes.gov/states/.

Energy/Emission analysis:

First, this analysis breaks down the individual components of the *Green Building Program* showing that, for the most part, the efficacy of these components is analyzed elsewhere in this report (the applicable Measure is highlighted) or considered outside the boundary of the regional GHG inventory. The major component of the Program that is not applicable to any other measure is exceeding the current local energy code (IECC 2006). Fortunately, great and local data exists to project energy and emission savings potentials if the IECC is updated to 2009 and to 2012. Given the energy savings outlined below, this analysis assumes an adoption of the 2012 (thus skipping the 2009 update) and commencing the enforcement January 1, 2013.

INDIVIDUAL COMPONENTS:

Resource Efficiency:
- Advanced Framing: this could result in a 20% reduction in lumber.[4] Collaboration with the residential build codes department would need to happen, but given that Tucson is not in a high wind or seismic zone, the results could result in approximately $1,000 savings per home. [5]
- HVAC that does not use refrigerants or non-HCFC refrigerants.
- Materials with recycled content.
- 18% fly-ash.
- *Emission abatement potential for implementing these measures is considered to be outside the local GHG inventory.*

Construction Waste Management: NA (see Measure G9- C&D Recycling).

Energy Efficiency:
- Passive Solar Design: Not analyzed.
- Energy Star Appliances: (see Measure E10 Promotion of Energy Efficiency through Construction Permitting).
- Energy Star Lighting Package: Covered by upgrading to the IECC 2012.
- Passive Solar Ventilation Pre-heater: Not analyzed.
- Install Solar Thermal Hot Water: (see Measure G2d Residential Thermal).
- Install Solar PV: (see Measure G2e Residential PV).
- Performance Path: Based on exceeding by 15% the current (2006) International Energy Conservation Code- please see the analysis below relative to upgrading to the 2012 IECC.

Beyond the above listed individual energy efficiency measures, the *Program* also includes picking one of two outlined paths for further energy efficiency points. These paths are:

Energy Program Path:

- WA would not suggest using the TEP Guarantee Home “Energy Program Path” as it mandates a guarantee home must have an electric water heater.[6] This is in direct conflict with one of the most promising Measures considered in this report (see G2d Residential Thermal).

Prescriptive Path:
- ACCA Manual J: Already required in IRC 2006, which is the building energy code of Tucson.
- Energy Star rated windows: Covered by upgrading to the IECC 2012.
- Insulation Grade 1 and reducing air leakage (20% savings in heating cooling): Covered by upgrading to the IECC 2012.
- Energy Star Cool Roofing: (see Measure G8 Mandatory Cool Roof).

The above items are the individual components of the *City of Tucson Green Building Program*. Therefore, the major component worth evaluating is increasing the new building’s energy performance over that of the currently adopted energy code. In the case of Tucson, this is the 2006 IECC. To this end, we evaluate the impact of upgrading to the 2012 IECC. The inputs, assumptions, and outputs for both residential and commercial construction are highlighted below.

Residential:
The per-home energy savings resulting from upgrading from IECC 2006 to 2012 for residential construction in the Phoenix area to be approximately 28%.[7] The average cost per square foot associated with adopting the 2009 IECC energy code over the 2006 IECC are approximated to be $0.34 / sqft for an energy savings of 17%.[8] Extrapolating that cost per square foot to the associated energy savings (ie, a linear relationship going from 17% to 28%) while assuming the average new home size at 1,800 sqft, the cost per home to upgrade from the 2006 to the 2012 IECC is approximately $1,000.

New home construction is assumed to average 3,500 homes per year at a 90% occupancy rate through 2020, which is consistent with all other measures in the report. The yearly energy usage of an average Tucson home is:
- Electricity: 11,000 kWh [9]
- Gas: 408 therms.[10]

Using the above inputs, the energy savings is calculated to be over 1.6 million tCO_2e over the life of the homes built with the newly adopted code (ie, through 2039). The abatement in 2020 totals over 82,000 tCO_2e.

Commercial:
Costs to upgrade commercial construction to the 2012 IECC is assumed to be 1.5 times the per square foot cost of residential as identified above. New commercial construction

is assumed to average 1 million square feet per year through 2020, which is consistent with all other measures in the report. The average yearly commercial square foot energy is: [11]

- Electricity: 17 kWh/sqft/yr
- Gas: 0.329 therms/sqft/yr.

Using the above inputs, the energy savings is calculated to be over 730,000 tCO_2e over the life of the commercial space built with the newly adopted code (ie, through 2039). The abatement in 2020 totals over 36,000 tCO_2e.

Remodeling:
Due to the restrictiveness of the remodel guidelines and the lack of good data to support our calculations, remodeling was excluded from the analysis. The *Green Building Program* designates remodels to be over 500 square feet but within renovating 75% of the structure or replacement of all major systems.[12]

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[13]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Upgrading the Energy Code to 2012 IECC		
Contribution of G22 Expand Green Building Program / Energy Codes:	114,235	tCO_2e
2020 Contribution of G9 Mandatory C&D Recycling (assuming 80% mandate):	5.04	%

Economic analysis:

The cost analysis uses the calculated cost of $1,012 per home for residential construction, $0.843 per square foot for commercial construction, the energy forecast pricing outlined in the appendix of this report, and the above mentioned projected yearly construction.

The total costs to implement are as follows:

- Residential (2011-2020): $114.7 million
- Commercial (2011-2020): $30.4 million.

The total savings over the life of the program due to reduced energy usage:

- Residential (2011-2039): $279.1 million
- Commercial (2011-2039): $97.6 million.

The net savings over the life of the program (savings-costs):

- Residential (2011-2039): $164.4 million
- Commercial (2011-2039): $67.3 million.

The total net savings over the life of the program (residential + commercial) is $231.6 million.

The total tCO_2e abated over the life of the program is 2.376 million. The resulting net savings per tCO_2e abated is:

- ***Savings*** per tCO_2e = ***$ 97 / tCO₂e***

The cost to implement per tCO_2e is $61.

Co-benefits:

Some co-benefits associated with green building practices include: [14]

- Green buildings generate an average increase of 7.5 percent in a building's value and a 6.6 percent improvement in return on investment, while decreasing operating costs by 8 to 9 percent
- Higher revenue due to higher rents and occupancy rates. Vacancy rates of green buildings are lower than existing buildings
- Improved indoor air quality in green buildings result in reduced absenteeism, and possibly higher productivity.

Equitability:

There are no apparent equitability issues.

Potential unintended consequences:

None identified.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://cms3.tucsonaz.gov/files/dsd/CityofTucsonGreenBuildingProgram.pdf

[2] Ibid.

[3] http://cms3.tucsonaz.gov/pdsd/codes-ordinances/building-codes

[4] http://cms3.tucsonaz.gov/files/dsd/CityofTucsonGreenBuildingProgram.pdf

[5] http://www.toolbase.org/PDF/DesignGuides/advancedwallframing1.pdf

[6] http://tucsonelectric.com/Green/GuaranteeHome/AboutGuarantee.asp

[7] http://www.energycodes.gov/publications/techassist/residential/Residential_Arizona.pdf

[8] http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/average-cost-meeting-2009-iecc-not-much

[9] http://www.tucsonelectric.com/faqs/faqlist.php?faq=SolarPV

[10] Derived from SW Gas 2009 Annual Report for all their service areas. http://www.swgas.com/annualreport/swg_annual_report_2009.pdf assuming 90% of their customers are residences

[11] http://www.esource.com/BEA/demo/PDF/CEA_offices.pdf

[12] http://www.pimaxpress.com/Documents/Green/PC%20Regional%20Residential%20Green%20Remodeling%20Standard.pdf

[13] PAG Regional Greenhouse Gas Inventory- 2010

[14] http://www.greenbiz.com/business/research/tool/2009/09/16/benefits-green-building-and-retrofits

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Measure: Mandatory Cool/Energy-Star Roofing (G8)

Mandate use of cool roofing systems in Tucson on all future residential and commercial construction.

COT ARRA RFP Summary:

Emission reduction potential:	84,359 tCO_2e
Percentage of goal (2012):	0.44%
Percentage of goal (2020):	3.7%
Total annual average implementation costs:	Competitive with traditional roofing; no public funds or incentives required
Entity that bears the costs of implementation:	Developers
Cost/Savings per tCO_2e:	\$115 / tCO_2e
Net annual savings:	\$216 / home
Entity that realizes the financial return:	Homeowner; commercial building owner
Equitability (progressive/regressive, income/revenue neutral, etc):	Income/revenue neutral
Potential unintended consequences:	None

Background information:

Energy Saving Roofing: The term “cool roofs” is a generic term for roofing materials, inclusive of Energy Star products, that lower heat transfer to the building below. According to the third party, non-profit Cool Roof Rating Council, a cool roof “*reflects and emits the sun's heat back to the sky instead of transferring it to the building below*”.[1] The roofing material does this via two drivers: solar reflectance and thermal emissivity. Solar reflectance is a material’s ability to reflect solar radiance, and thermal emissivity a material’s ability to release absorbed heat. It is important to note that the material need not be white (or similar).

Using such materials on roofs keep the roof and the building cooler than they would have been with traditional roofing. Thus, building and homeowners can lower the building cooling needs at relatively low cost, especially when the roofing project is integral with new construction or during roofing replacement. The use of this low cost, regionally appropriate measure can help Tucson citizens lower their energy bills, achieve important GHG emissions reductions, and help reduce the Urban Heat Island (UHI) effect.

Business as Usual:

Absent increased incentives and/or mandating cool roofing systems, this cost- and energy-saving measure could continue to go underutilized in the region. Tucsonan homeowners are currently missing out on over 2,200 kWh of savings per year by not installing such systems.

Description of Measure and Implementation Scenario:

The proposed measure is implementation of cool roof materials on all new home and commercial construction via a building code requirement. Projected annual new home occupancy is 3,150 homes (assumed to have a roofing area of 1,800 sqft) and 25 commercial buildings (assumed to have a roofing area of 25,000 sqft). The life cycle analysis is run for 10 years.[2] An average premium for flat and pitched cool roof materials is assumed to be $0.05/sqft installed.[3]

Has the Measure been implemented elsewhere and with what results?:

In October 2005 cool roofs became mandatory on all non-residential, low-sloped construction and re-roofing projects in California via their Title 24 Building Energy Efficiency Standards. The 2008 update to Title 24 covers may more structures, including residential and high-sloped roof applications.[4] Other States and cities have since followed in similar fashion (for example, Georgia, Florida, Chicago and Philadelphia). [5] [6]

Currently, the State of Arizona mandates cool roofs only on State owned and funded buildings despite some very convincing case studies that implementation has energy and cost saving benefits.[7] Tucson hosted a case study on the 23,400sqft Thomas O. Price Service Center office building. During the study, cool roofing was found to save up to 50% of cooling costs to the property.[8]

Energy/Emission analysis:

Description	***Input***	***Notes***
New Single-Family Home Mandate Inputs		
New home construction average per year (minus projected vacancies)	3,150	
Average home roof size (sqft)	1,800	
Average annual electricity usage (kWh)	11,000	
Home AC electricity usage as a percentage of total (%)	50%	
Average annual electricity usage for AC per home (kWh)	5,850	
Assumed home AC savings per home via utilizing cool roof (average over year) (%)	40%	
Average annual electricity savings via utilizing cool roof (kWh)	2,200	
gCO_2e per kWh	856	Derived from PAG's GHG Inventory 2010
New Commercial Construction Mandate Inputs		
Commercial construction projects added per year	25	
Average roof square footage per project	25,000	
Projected electricity savings per project	117,000	See note (8) - converted from Btu

New Single-Family Home Mandate Totals over 10-years		
Total homes covered by policy	31,500	
Total electricity savings (2020)	69.3 M	kWh
Resulting GHG mitigation potential	59,321	tCO_2e

New Commercial Construction Mandate Totals over 10-years		
Total commercial projects added per year	25	
Total electricity savings (2020)	29.3 M	kWh
Resulting GHG mitigation potential	25,038	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[9]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Mandatory Cool Roof- New Single-Family Homes		
Contribution of G8 Mandatory Cool Roof (2020):	59,321	tCO_2e
2020 Contribution of G8 Mandatory Cool Roof:	2.6	%
Mandatory Cool Roof- New Commercial Construction Projects		
Contribution of G8 Mandatory Cool Roof (2020)	25,038	tCO_2e
2020 Contribution of G8 Mandatory Cool Roof:	1.1	%

Economic analysis:

The economic analysis, run over a 20-year life of the roof, for the new home mandate considers the following inputs:

- The premium cost of cool roofing products is approximately $0.05[3]

- The costs per kWh are per the future energy price forecast included in this report's appendix

Given these parameters, the savings derived from reduced electricity bills result in a payback of choosing a cool roof over traditional roofing materials of less than 1 year. Over the 20-year life, the savings to the homeowner equal $4,316.

- The resulting abatement ***savings*** per tCO_2e = ***$114.60*** $\boldsymbol{tCO_2e}$

Dr. Lisa Gartland's produced a report to the City of Tucson received a grant from the Public Technology, Inc.'s (PTI) Urban Consortium Energy Task Force[8] to analyze implementation of cool roofing on a commercial project with an existing roof that apparently was not due for replacement. Even under these circumstances, the payback for the project as a result of energy savings of approximately $4,000/year was under 6 years. The rate of return for the project was calculated to be 16%.

Co-benefits:

Cool roofs provide an array of co-benefits above energy savings to various stakeholders.[10] They add to a building's comfort, they add life to air-conditioning capital investments, and they possibly extend the life of roofs. Moreover, reduction of energy demand during peak times can lead to not only energy savings but more stability in the electric grid.[11]

Cool roofs also provide a measure that helps mitigate Urban Heat Island effect via lowering ambient air temperatures, thus being synergetic with Tucson's probable adaptation strategies.

Equitability:

Income/revenue neutral due to cost competitiveness with traditional roofing projects.

Potential unintended consequences:

There may be some small increases to home heating bills in the winter months. However, due to the low angle of the sun and the minimal amount of heating in the region, these small increases are considered negligible.[12]

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.coolroofs.org/

[2] 10 years is a very low manufacturer's roofing warranty for EPA Energy Star approved products: http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=RO

[3] Derived from http://www.epa.gov/heatisld/mitigation/coolroofs.htm; however, cool roofing systems may, in fact, extend the life of the roofing system thereby lowering a building's total life roofing costs (see co-benefits section).

[4] http://www.energy.ca.gov/2010publications/CEC-400-2010-005/CEC-400-2010-005.PDF

[5] http://www.epa.gov/heatisld/resources/pdf/CoolRoofsCompendium.pdf

[6] http://www.phila.gov/green/greenworks/energy_target2.html

[7] http://www.coolroofs.org/codes_and_programs.html

[8] http://cms3.tucsonaz.gov/files/energy/CoolCommPh2-Dr.GsFinalReport-COVERPG.pdf

[9] PAG Regional Greenhouse Gas Inventory- 2010

[10] http://continuingeducation.construction.com/article.php?L=68&C=488&P=2

[11] http://www.coolroofs.org/documents/IndirectBenefitsofCoolRoofs-WhyCRareWayCool.pdf

[12] http://www.coolroofs.org/HomeandBuildingOwnersInfo.html

Measure: Residential Thermal (G2d)

This measure analyzes two different implementation scenarios for increased usage of Solar Hot Water systems in Tucson:

1. Increase access to low-interest financing for capital costs
2. Mandate a solar hot water system on all new residential construction.

* NOTE: The calculations were done contemplating that all new construction water heaters are electric. Gas water heaters emit approximately 2/3 less CO_2e than their electric counterparts.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	82,908 (This would be reduced to ~55,000 if gas v. electric heaters were installed 50/50 in new home construction)
Percentage of goal (2012):	0.43%
Percentage of goal (2020):	3.7% (or 2.4% if gas v. electric heaters were installed 50/50 in new home construction)
Total annual average implementation costs:	$108 (after rebates assuming 20-year life)
Entity that bears the costs of implementation:	Homeowner
Cost/Savings per tCO_2e:	$138 / tCO_2e
Net annual savings:	$162 / home
Entity that realizes the financial return:	Homeowner
Equitability (progressive/regressive, income/revenue neutral, etc):	Only effects participants
Potential unintended consequences:	Possible increased water usage

Background information:

Solar hot water heaters utilize the sun's radiance to augment, or sometimes completely offset, the need for conventional water heating systems, which rely on fossil fuels via electricity and/or natural gas.

Aggressively incentivizing such systems in areas with abundant solar resources (such as Tucson) can lead to quantifiable GHG emission reductions with a net cost savings to the homeowner and payback periods in the range of 5 – 20 years (with The Solar Store estimates ranging from 3-7 years).[1]

Systems for residential use, typically referred to as Solar Domestic Hot Water (SDHW), are comprised of one to two storage tanks and either active or passive solar collectors.[2] For more information on the mechanics of the three primary solar collectors as well as descriptions on active versus passive systems, please see the DOE Energy Savers website under Note (2). As opposed to educating on the mechanics and science, this analysis seeks to quantify the practical implementation of wide-use SDHW systems with Tucson, focusing on systems and energy savings that are most applicable to the region. Fortunately, a unique non-profit, the Solar Rating and Certification Corporation (SRCC), exists that certifies solar energy products and provides regional average annual energy savings.[3]

Under current, local incentive structures, there is a wide range of net installed costs among systems ranging from $4,000 to $7,000 depending on the type of system. Savings to the homeowners can total $270 annually from reduced energy use.

Business as usual:

Absent increased incentives and/or mandating solar hot water systems, this cost- and energy-saving measure could continue to go underutilized in the region. Tucsonan homeowners are currently missing out on over 2,700 kWh of savings per year by not installing such systems.

Description of Measure and Implementation Scenario:

The carbon and economic analysis assumes homeowners install a SDHW system that meets the industry OG-300 standard (also a TEP rebate requirement). Implementation scenarios to increase the amount of SDHW uptake in the City are based on:

1. Increasing homeowners' access to financing repaid via property tax increase over the life of the loan. Uptake is assumed to be 372 homes per year.

2. Following the State of Hawaii's lead in mandating SDHW on all new home construction. New home construction projections are based on 3,500 homes per year with a home occupancy rate of 90%.[4]

Whether or not additional financing is made available to property owners, this measure can be combined with the Residential Community Climate Challenge (Measure E14). As the Climate Challenge is a public education campaign, marketing of the financial and energy savings need to be made clear to potential participants.

Has the Measure been implemented elsewhere and with what results?:

The City of Berkeley implemented a Financing Initiative for Solar and Renewable Technology (FIRST) pilot program that is intended to assist homeowners with the capital costs of installing solar energy systems.[5] FIRST allows a citizen to borrow money from the City, which is then paid back over the life of the loan via increases in their property tax bills, and the City of Berkeley has produced a implementation guide for local governments.[6] Property tax based financing has now gained traction and is commonly referred to as PACE (Property Assessed Clean Energy) financing. According to the Alliance to Save Energy: [7] [8]

> "*PACE financing allows property owners to benefit from energy savings immediately while spreading the cost of improvements over a number of years. The PACE model addresses and overcomes challenges that both borrowers and lenders have identified in seeking to use traditional finance mechanisms to fund efficiency improvements.*"

Berkeley's pilot can be considered a success. They targeted 40 homes an ended with 13 PV systems installed under the FIRST mechanism and more via home equity loans (due to the more favorable interest rates). According to the survey in their assessment, knowledge of and access to financing to overcome the capital costs of utilizing solar PV had significant influence in their participation[4].

Via legislation SB644, Hawaii has mandated that all new single-family homes include a SDHW system.[9] In the Bill's language, the legislature estimates that the mandate could mitigate 10,260 tons of GHG emissions per year based on a projection of 5,700 homes built per year.[10] (NOTE: this projection of 1.8 tons of CO_2e per home per year is similar to the below projected 2.4 tCO_2e savings for Tucson.)

Energy/Emission analysis:

An SDHW system that meets the OG 300 standard can be expected to save 2,750 kWh of electricity per year.[11]

Description	***Input***	***Notes***
Expected annual electricity savings of a OG 3000 SDHW system in Tucson, AZ	2,750	kWh
COT electricity grid emissions factor	856	gCO_2e
Expected annual GHG savings per home per year	2.4	tCO_2e
Incentives		
Homes assumed to utilize increased incentives and install SDHW per year	372	See economic analysis for incentives
Resulting GHG mitigation potential (2020)	8,757	tCO_2e
New Single-Family Home Mandate		
Projected occupied new homes annually	3,150	
Resulting GHG mitigation potential (2020)	74,151	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[12]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Residential Thermal- Increased Uptake via Incentives		
Contribution of G2d Residential Thermal (in 2020):	8,757	tCO_2e
2020 Contribution of G2d Residential Thermal:	0.39%	%
Residential Thermal- New Single-Family Home Mandate		
Contribution of G2d Residential Thermal (in 2020):	74,151	tCO_2e
2020 Contribution of G2d Residential Thermal:	3.27	%

Economic analysis:

Description	*Input*	*Notes*
Annual home electricity use in Tucson	11,000	kWh
Percentage of electricity consumed for water heating	25%	
Annual electricity use for water heating	2,925	kWh
Electricity costs per kWh	$0.08	Assumed to increase per this report's Energy Forecast
Capital cost of SDHW system	$7,000	
TEP Upfront Incentive (UFI)	$750	
TEP Performance Incentives (spread over 2 years)	$1,000	
Expected annual electricity savings	2,750	kWh
Federal rebate (30%)	$2,100	
State rebate (25%, max $1,000)	$1,000	
Cost after rebates	**$2,150**	
Life of analysis	20 years	

Based on the above inputs, the total savings to a homeowner retrofitting their current conventional system with SDHW has a net present value of $3,239 with a payback period of under 10 years. The savings are increased if the homeowner has to replace their current conventional system and is choosing between the two systems.

- ***Savings*** per tCO_2e = ***$137.60 / tCO_2e***

Co-benefits:

Installation of SDHW systems cushion owners from fossil fuel rate spikes and it is reported that energy efficiency upgrades increase home resale values.[13] Moreover, incentivizing accelerated uptake of clean technology can help spur the local economy and small businesses. It also helps in job creation based on the new demand for skilled and knowledgeable plumbers. Lastly, this Measure is synergetic with the Community Climate Challenge (Measure E14), and the two, among others, should be considered in concert.

Equitability:

PACE type loans effect only those who choose to participate in the program, whereas Feed-In-Tariffs (FITs) such as Tucson Electric Power's Renewable Energy Standard Tariff (REST) affects all consumers of the utility. For this reason, this program is more equitable by not charging households in every income bracket a flat rate

Potential unintended consequences:

A potential negative unintended consequence is the increased use of water due to the availability of low cost hot water for domestic use. Another potential negative outcome is that the retrofit may not be permanent. The current homeowner could decide to go with a "conventional" system at the end of the SDHW system's life.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.solarstore.com/index.php/faqs/1-solar-faqs/21-incentives-what-is-the-payback-time-for-a-solar-water-heater-

[2] http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12850

[3] Solar Rating and Certification Corporation: http://www.solar-rating.org/

[4] Derived from: http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=16000US0477000&-qr_name=ACS_2009_5YR_G00_DP5YR4&-ds_name=ACS_2009_5YR_G00_&-_lang=en&-_sse=on

[5] Berkeley FIRST Initial Evaluation: http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Berkeley%20FIRST%20Initial%20%20Evaluation%20%20final%20(2).pdf

[6] http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Guide%20to%20Renewable%20Energy%20Financing%20Districts2009.pdf

[7] http://ase.org/sites/default/files/PACE_factsheet.pdf

[8] Currently, many such financing mechanisms are suspended due to a controversy that Federal Housing Finance Agency is unwilling to accept mortgages that have a PACE lien to reduce their liability relative to mortgage defaults.

[9] http://www.cleanenergyauthority.com/solar-energy-news/solar-hot-water-heaters-mandatory-in-hawaii/

[10] http://www.capitol.hawaii.gov/session2008/bills/SB644_cd1_.htm

[11] See TEP Green Energy- Solar Hot Water FAQs: http://www.tep.com/Green/Home/Solar/spaceheating.asp

[12] PAG Regional Greenhouse Gas Inventory- 2010

[13] http://www.nrel.gov/docs/legosti/fy96/17459.pdf

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Measure: Commercial PV (G2a)

Increase uptake of both large and small commercial PV systems 25% year-on-year totaling installed new capacity of 520 MW and 3.2 MW by 2020 per category, respectively.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	72,528 tCO2e
Percentage of goal (2012):	0.12%
Percentage of goal (2020):	3.2%
Total annual average implementation costs per business (small / large):	$2,012 / $44,673 over 20-yr life
Entity that bears the costs of implementation:	Business or property owner
Savings per tCO_2e (small / large):	$59 and $41 / tCO_2e
Net annual savings per business (small / large):	$2,012 / $ $10,591 over 20-yr life
Entity that realizes the financial return:	Ratepayer
Equitability (progressive/regressive, income/revenue neutral, etc):	Only applicable to business that participate
Potential unintended consequences:	Minimal

Background information:

Solar electric systems, or photovoltaic (PV), convert solar radiation into useful forms of energy. Solar resources are most abundant in the southwestern US, therefore making this location the most applicable for large-scale implementation.[1] Decentralized commercial PV in Tucson provides business- and property-owners with clean, renewable energy that helps offset their building's fossil fuel derived energy needs while utilizing the region's most abundant natural resource.

When coupled with energy conservation and energy efficiency, this supply-side solution can lead to important GHG emission reductions, spur local business, and create jobs. The major obstacle to such installations is the large capital investment of PV systems.

The utility, Federal, and State incentives for both large and small commercial are a complicated business. These incentives vary by system size and are fluctuating per year. Moreover, there is a wide spread of system sizes in both categories. The discussion below highlights the current rebates and incentives for the size systems contemplated in this analysis and gives endnotes for further incentive literature.

Description of Measure and Implementation Scenario:

The carbon and economic analysis assumes small commercial installations are, on average, 23.4 kW PV systems producing 39,780 kWh annually and that large commercial installations are 200 kW systems, which produce 304,920 kWh annually.[2] These sizes are the median sizes of all commercial systems in TEP's service area.[3]

The implementation scenario to assumes a 25% increase year-on-year from the current totals of reserved and installed systems within TEP's service area.[4]

Has the Measure been implemented elsewhere and with what results?:

Solar energy, and the associated uptake in both residential and commercial markets, has been a topic of national and local energy policy for decades. The more topical discussion is around the future of implementation incentives and energy codes.

According to the International Energy Agency, regionally relevant *Key Actions* for the next ten years include: [5]

- *Provide long-term targets and supporting policies to build confidence for investments in manufacturing capacity and deployment of PV systems.*
- [Continue to] *implement effective and cost-efficient PV incentive schemes that are transitional and decrease over time*[6] *so as to foster innovation and technological improvement.*

- *Collaborate across jurisdictions to reform local building codes and standards to facilitate PV implementation and integration.*

Energy/Emission analysis:

Description	***Input***	***Notes***
Expected annual electricity production of a typical commercial PV system (small/large)	39,780 / 304,920	kWh
Expected annual GHG savings per year (small/large)	34 / 261	tCO_2e
Commercial PV uptake		
Installation increase per year above total current systems	25%	Current systems:
Combined GHG mitigation potential over 10-year life of program	72,528	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline): [7]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Residential PV- Increased Uptake		
Contribution of G2a/c Commercial PV in 2020:	72,528	tCO_2e
2020 Contribution of G2a/c Commercial PV (over 10-yrs):	3.2	%

Economic analysis:

This analysis is completed from the business-owner perspective. For a complete listing of incentives and rebates, please see dsireusa.org.

Description	***Input***	***Notes***
System cost per W	\$6.20 / \$6.74	Small / large
Electricity costs per kWh	\$0.08 sml \$0.05 lrg	Assumed to increase per this report's Energy Forecast (see appendix)
Capital cost of system	\$40K / \$1.35M	Small / large
TEP Upfront Incentive (small only)	\$46,800	\$2/Watt
TEP Performance Based Incentive (PBI)	\$0.12[8]	This rate is bid on
State rebate (10%- Max \$25K per location and 2 locations per business)	\$14.5K / \$50K	Small / large
Federal rebate	\$43.5K / \$404K	30% of gross amount[9]
Upfront cost after rebates	**\$40.2K / \$893K**	Large commercial TEP rebate is paid over time
Life of analysis	20 years	

Based on the above inputs, the total savings to a small business owner installing a 23.4 kW PV system has a payback period under 12 years, and a large commercial installation has is paid back in under 17 years.

The small system has a savings of over \$42K over the 20-year life of the system, and the large system's savings is over \$211K over the same life. This results in the following ***savings*** per ton:

- Small commercial ***savings*** per tCO_2e = ***\$59 / tCO_2e***
- Large commercial ***savings*** per tCO_2e = ***\$41 / tCO_2e***

Co-benefits:

Installation of PV systems cushion owners from fossil fuel rate spikes. Moreover, incentivizing accelerated uptake of clean technology can help spur the local economy and small businesses. It also helps in job creation based on the new demand for skilled and knowledgeable electricians. Lastly, this Measure is synergetic with the Climate Wise Measure (E7), and the two, among others, should be considered in concert.

Equitability:

Such systems are only impact those who participate in the program.

Potential unintended consequences:

A potential negative unintended consequence is the increased use of electricity due to the availability of lower cost energy. Another potential negative outcome is that the retrofit may not be permanent. The current homeowner could decide to go with a "conventional" system at the end of the PV system's life.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10710

[2] TEP's website still shows that the cutoff between small and large commercial is 20 kW. The ACC increased that cutoff to 100 kW February 1, 2010 (http://tfssolar.com/3135/increased-incentives-help-tucson-businesses-tap-the-sun/)

[3] The median was used in lieu of the mean due to very large systems in each category skewing the numbers.

[4] Current reserved and installed systems are: large = 33 and small = 13 as of December 31, 2010 as found at arizonagoessolar.org.

[5] IEA's *Technology Roadmap: Solar Photovoltaic energy*. Available at: http://www.iea.org/papers/2010/pv_roadmap.pdf

[6] The IEA's Roadmap projects parity in energy production pricing between fossil fuels and solar in 2020 for many regions.

[7] PAG Regional Greenhouse Gas Inventory- 2010

[8] The current and near-future bidding price for large commercial solar of $0.12 is information obtained during a December 1, 2010 conference call with Bruce Plenk, the City of Tucson's Solar Coordinator.

[9] PV owners will have to pay income taxes on the federal rebate via a 1099 form.

Measure: Expanded Residential Energy Efficiency (G14, G14a, G14b)

Design and implement an aggressive residential energy efficiency promotion campaign, using actual savings and co-benefit experiences to emerge from the new ARRA and TEP home efficiency upgrade initiatives.

These programs are consistently showing the potential for up to 3,500 kWh/year in energy savings per participating residence. With the large universe of Tucson homes built prior to the development of energy codes (early 1980s), there is a significant potential to achieve energy, cost and emissions reductions from even small expenditures toward home energy efficiency.

Emission reduction potential by 2020:	47,143 tCO_2e
Percentage of goal (2012):	0.3%
Percentage of goal (2020):	2.0%
Total annual average implementation costs:	$1.345 million
Entity that bears the costs of implementation:	Homeowners ($1.32 million) and City of Tucson ($25,000/yr)
Cost/Savings per tCO_2e:	$61 savings
Net annual savings over 9 year program:	$1.6 million/yr
Entity that realizes the financial return:	Homeowners (energy savings), City of Tucson (through sales tax revenue), energy efficiency supplies and service sector
Equitability (progressive/regressive, income/revenue neutral, etc):	Likely to be progressive by saving of utility bills for lower income homeowners.
Potential unintended consequences:	Poor quality workmanship that leads to possible indoor air quality issues or lower than projected energy savings.

Background information:

Residential energy use in the City of Tucson represents the City's second largest greenhouse gas emissions source.[1] Although the most cost-effective method for reducing energy use in the housing sector over time is to achieve energy efficiencies in new homes, another method is to improve the energy efficiency of existing homes. This is achieved in some cases with initial energy audits followed by installation of least-first-cost efficiency improvement measures.

Other approaches use specific energy savings targets to drive retrofit program activities or have specific cost-per-house values set for efficiency improvements. An inventory of over 100,000 single-family, owner-occupied homes exist in the City of Tucson, many of them constructed before the advent of even minimum building energy codes.

Approximately 15,300 homes will receive energy efficiency upgrades through existing programs through 2020 and these programs are outlined below. In addition, some homeowners have taken advantage of Federal and State energy efficiency tax credits the past two years. However, these tax credits have now been significantly diminished, leaving a significant pool of homes in Tucson whose owners would benefit from even minimum energy efficiency upgrades.

Recently, the City of Tucson has embarked on a home energy efficiency retrofit initiative funded under the American Recovery and Reinvestment Act. A contractor to the City is engaged in retrofitting 300 single-family homes. The amount of energy to be saved from the retrofit of these 300 homes has been estimated at 3,500 kWh/year/home.[2] First year savings would total 1,050,000 kWh.

Over the ten year and likely longer life of the measures installed (low-flow shower fixtures, solar shades, duct seals, weather-stripping, etc.) this would total a minimum of 10,500,000 kWh saved. Cost of materials and labor for the 300-home project totals $240,000, not including contractor overhead.

The Tucson Electric Power company is managing a second energy efficiency retrofit initiative in the City. Its TEP Existing Home Program (expected to have a new brand sometime early in 2011) involves a longer-term (than the City's ARRA initiative) program to meet required energy efficiency goals established by the Arizona Corporation Commission.

TEP is required to meet 22% of its 2020 demand (projected without the efficiency initiative) via energy efficiency, and has thus set out on an aggressive program that includes residential energy retrofits. While the program is still taking shape, this much is known.

In 2011, the utility's contractor is charged with conducting 1,000 home energy audits that are expected to result in the installation of 2,600 energy efficiency measures and have a collective savings of 2,052,850 kWh/year. This is a much more extensive program than that being undertaken by the City with ARRA funds, due to the ACC mandate and the efficiency target sought.

As the program ramps up through 2020, a higher and higher amount of annual (and cumulative) savings is expected from the anticipated 15,000 homes to be audited and upgraded over the decade (2011 – 2020).

Energy efficiency programs such as TEP's in Arizona are funded through a systems benefits charge collected on all customer electricity bills in a given utility service area. Elsewhere in Arizona, Arizona Public Service plans to continue to expand already successful energy efficiency programs to reduce use by 3,100 GWh by 2025.[3]

Finally, the Tucson Urban League (TUL) has received ARRA funding for a major increase in its home Weatherization Assistance Program (WAP) in the City, and will be spending up to $6,500 on energy efficiency upgrades to qualifying homes in its program.

Statewide, the ARRA-funded low-income weatherization program has completed 3,092 home retrofits as of January 5, 2011 resulting in homeowner savings of over $902,000 and an energy savings of 7,989,135 kWh. On average, this program has saved almost $300 per home in the program's first year with a related energy savings of 2,584 kWh/home.[4] The Arizona Commerce Authority maintains a website with streaming dollar and kWh savings from its statewide weatherization assistance program since its inception in September 2009.[5]

The above program highlights are provided as background to illustrate what is already underway in Tucson and the region and demonstrates the potential that several parties recognize for significant cost, energy, and emissions reductions as a result of existing home energy efficiency retrofits.

Business-as-Usual:

Business-as-usual results in the achievement of energy efficiency upgrades on over 15,000 existing homes in Tucson though 2020. While substantial, this represents only 15% of the existing single-family, owner-occupied homes in the City and only about 8% of the single-family residences total (including rentals and vacant homes). Additional potential for energy efficiency retrofits and associated cost savings is clearly available.

Description of Measure and Implementation Scenario:

COT should partner with TEP and TUL to promote the achieved energy and cost savings from programs now underway as a first step in encouraging other homeowners not yet participating in these programs to make EE investments.

On the basis of energy and cost savings emerging from the initial year or two of the TEP and ARRA programs, an effective and aggressive marketing campaign should be developed highlighting the economic return to homeowners and community at large (via the economic multiplier that accompanies consumer-retained utility expenditures) as well as the myriad of co-benefits that accompany residential energy efficiency gains.

The value of an aggressive outreach campaign cannot be underestimated, as most consumers do not have access to straightforward and reliable information about their home's energy use. Without this information, homeowners are less likely to invest in home energy upgrades. This is an area where City leadership and collaboration among those currently implementing energy efficiency projects can have significant payback.

The campaign should set a target of an additional 15,000 residences investing from $400 to $1,200 in energy efficiency improvements in their homes. The City might even sponsor a challenge program to identify and highlight through a recognition program those homeowners able to achieve the quickest and most cost-effective energy savings per dollar invested.

The City should also continue to monitor possible future use of a Property Assessed Clean Energy (PACE) mechanism to help assist homeowners with the up-front costs of these efficiency investments. Currently, this opportunity that was being implemented in around 400 cities and counties in 17 states is not currently available pending legal review of lien structuring and related securities issues.[6]

An additional implementation strategy would be to establish by ordinance a requirement that a certain level of quick-payback energy efficiency investments be required as a permit condition for residential renovations above a certain square footage or dollar amount.

Without going into the design of such a program, it could be based on existing and forecasted levels of residential renovations (room-add, new roof, code upgrades, etc.) and combined with the challenge campaign and ultimately a resurrected PACE program should that again become available in the next year or two. The goal would remain the same – 15,000 residences investing in energy efficiency retrofits above the numbers expected to be covered in the existing TEP and ARRA programs.

Note: This measure should be directed to homes which have not previously had energy efficiency upgrades nor which have been constructed since the advent of modern energy efficiency building codes in Tucson. This would include all homes built going forward through the remainder of the decade.

Energy/Emission analysis:

Using the actual and forecasted energy savings from home retrofit programs described above, an additional 15,000 homes investing in energy efficiency retrofits produce 52,500,000 kWh (15,000 x 3,500 kWh/unit) in energy savings at full program implementation (2020).

We project that 11% of the 15,000 homes are added as program participants each of the 9 years to 2020 beginning in 2012. Thus, 1,650 participating homes each year would result in energy savings of 5,775,000 kWh for the new retrofits in that year.

We project the average life of the energy efficiency improvements to be 20 years.

Greenhouse gas savings resulting from a program of this scale would be 5,238 tCO_2e in 2012, and 47,143 tCO_2e/year at full program implementation in 2020. The accumulated savings by 2020 is projected at 235,714 tCO_2e.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	47,143

Economic analysis:

Average program cost to homeowners would be $800 x 15,000 participating households, or $12,000,000.

Presumably, the entirety of these costs would be spent in the City of Tucson and thus represent taxable income to the retailers of energy efficiency material and services. The sales tax on $8,000,000 of energy efficiency materials (assuming 2/3 of program investments are in sales taxable investments rather than services), at the current Tucson sales tax rate of 2.5%, totals $212,000 over the 9-year program period.

It is impossible to predict whether these taxes would be additional revenues to the City or not – it depends on whether homeowners reduced other taxable expenses. Therefore, this potential economic benefit to the City is not counted in this analysis.

The expense of the City of Tucson's participation in a collaborative energy efficiency campaign would need to be covered by an estimated 0.5 FTE/year for the nine years of the implementation period analyzed (2012 – 2020), for a total cost of $445,000.

A small surcharge similar to the current system benefits charge on electric bills could spread implementation costs to the entire rate base. This approach makes sense because the electricity savings achieved in a broad energy efficiency retrofit program will delay the need for new powerplants, helping to keep electric rates low.

Homeowner savings will be about $462,000 in the first year at $0.08/kWh residential electrical rates. As electric rates increase (we have projected 2.4% per year) the savings increase as well. By 2015 the program will be responsible for savings to Tucson residents of $6.7 million; by 2020 the program will have saved a total of $26.9 million.

Net Economic Impact

Program costs: $12,000,000 investment by homeowners plus $445,000 administration
Benefits: $26.9 million saved by 2020; total program savings $116.8 million through 2040.

Net savings through 2020: $26.9 million less $12.45 million = $14.45 million.

The savings per tCO_2e saved through 2020 are: 14,450,000 divided by 235,714 = $61.

Using a 1.5 multiplier, the positive economic impacts of the energy savings would be $21.68 million.

<u>Co-benefits:</u>

There are multiple co-benefits that accompany the immediate energy and cost savings that flow from energy efficiency retrofits to currently energy-inefficient residential homes in Tucson. These co-benefits include:

1. An increase in home comfort as cooling and heating systems deliver more of their intended benefits to the conditioned space

2. Likely delay in utility need to build new power plants thus minimizing rate increases owing to new capacity additions

3. Increased adaptive capacity to temperature extremes expected as long-term climate warms in the southwest

4. An increase in property resale values as energy efficiency gets built into a home

Equitability:

No real equitability issues are raised with a voluntary outreach program. Even the lower cost end of efficiency upgrades now taking place are expected to deliver quick payback, so efficiency improvements made are not limited to those at higher income levels.

Potential unintended consequences:

Certain weatherization measures will have the intended effect of making homes tighter to the outside air. Thus, care must be taken that qualified and trained personnel are used to both conduct residential energy audits and perform efficiency upgrades. Efficiency technology installers must be able to identify and exclude from home retrofit programs those homes with attributes not conducive to certain efficiency measures by creating indoor air quality problems (mold, asbestos, etc.).

Similarly, proper bonding and security concerns must be addressed by any potential efficiency program workforce to the degree acceptable to the funding entity or otherwise required by law. Both of these concerns have been customarily addressed in responsible residential retrofit programs.

Endnotes

[1] Regional Greenhouse Gas Inventory. Pima Association of Governments. October 2008.

[2] Personal Communication with Vanessa Richter, Conservation Services Group. January 2011.

[3] American Council for an Energy Efficient Economy. 2010. http://www.aceee.org/sector/state-policy/arizona

[4] Arizona Commerce Authority. Low-Income Weatherization Assistance Program, January 2011, at: http://www.azcommerce.com/Energy/Low-Income+Weatherization+Assistance+Program.htm.

[5] Arizona Commerce Authority. 2011, at: http://www.azcommerce.com/Energy/Low-Income+Weatherization+Assistance+Program.htm.

[6] "Fannie Mae and Freddie Mac Deliver Blow to Popular Solar Energy Program." *Green American*, September/October 2010.

Measure: Enhanced Direct Load Control in Commercial Buildings (G6a)

Require by ordinance that all new commercial buildings be fitted with dynamic load control technology, such as smart electricity meters, at the time of construction. Developers will be encouraged to work closely with TEP to take advantage of possible future incentives for deployment of direct load control systems or smart meter technology. The systems installed must provide real-time electricity consumption information to building tenants.

The City will also work with TEP to promote the advantages of voluntary direct load control retrofits to existing commercial buildings with the goal of having 10% of existing, occupied commercial space participate by end of 2013.

Studies where direct load control systems such as smart meters have been deployed indicate an average energy savings of as high as 12%/year as a result of changes in consumer energy consumption behavior due to information from smart meters.

Emission reduction potential by 2020:	33,301 tCO_2e/yr.
Percentage of goal (2012):	NA
Percentage of goal (2020):	2.5%
Total annual average implementation costs:	$10,133
Entity that bears the costs of implementation:	Commercial / industrial building owners
Cost/Savings per tCO_2e through 2020:	Savings $133/$tCO_2e$
Net annual savings in 2020:	$8.32 million
Entity that realizes the financial return:	Commercial and industrial businesses
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	0

Background information:

Direct load control systems, which include but are not limited to smart meters, represent the next generation of electricity meter. They signal the end of estimated utility bills and monthly meter readings by providing customers and energy suppliers with accurate information on the amount of energy being used on a real or near real-time basis. The key attribute advanced with smart metering is the concept of dynamic utility pricing.

One simple approach is time-of-use-pricing, where demand-based fixed pricing bands are established by the utility and consumers can choose to modify demand with these pricing bands (peak, off-peak, shoulder) in mind. A second form of dynamic pricing is real-time pricing with prices altered on a systematic, scheduled basis (hourly, half-hourly) and meters receiving and displaying the price to the customer who can moderate consumption behavior accordingly.

In each case, consumers have information that enables more informed decision making and choices as to times and amounts of energy they wish to use. Reductions in energy demand are almost always achieved as consumers respond to the availability of information from smart energy meters.

Status Quo / Business as Usual:

At the beginning of 2009, the most recent year with full-year data, there was an estimated 103.5 million square feet of commercial (industrial, retail, office) space in Tucson.[1] Construction of an estimated 700,000 additional square feet of combined retail, office, and industrial space was expected to be completed in 2010.[2]

Deployment of direct load control systems or any other type of smart metering in the existing 103.5 million square feet of commercial sector in Tucson, or in the new construction sector, is not yet common. Thus new commercial building and most all existing commercial building tenants (which have not independently adopted some form of smart metering on their own) cannot take advantage of accurate and timely pricing signals for electricity consumption and miss the cost savings that these price signals offer as described in more detail below.

Tucson Electric Power has two forms of time-of-use metering available to commercial customers. The first is called Power Shift. A Power Shift meter tracks the number of kWh a customer uses and the time used. The time of use meter installed lets TEP know how much electricity was consumed during peak, shoulder, or off-peak periods so it can apply the appropriate rate for each period's consumption.[3]

The second type of program TEP offers is called DemandSMART[4] that it makes available to commercial, institutional, and industrial customers in its service area. Program participants voluntarily reduce their electric consumption during times of peak electricity demand or high wholesale electricity prices and receive recurring payments in return for participating during these events.

Neither program offers the advantages of dynamic real-time pricing. The Power Shift metering only provides immediate information in one direction, to the utility. Information back to the customer comes later at billing, so the customer does not receive the immediate time-of-use price signals possible under advanced smart meter approaches.

DemandSMART customers receive compensation based on reduced electricity demand during utility-defined events but there is no immediate price signal on savings to alert the customer just how much peak or other event pricing periods cost compared to off-peak usage.

Description of Measure and Implementation Scenario:

This measure recommends that the City of Tucson require by ordinance that developers of all new commercial buildings, in consultation with Tucson Electric Power, install a direct load control system (or multiple systems if the property is to be used by more than one tenant) in commercial properties they build before occupancy may take place.

The systems should be able to provide dynamic pricing signals to tenants and allow for tenant-choice on whether to participate at a given time and at a specified price. This measure is intended to spur energy efficient behavior of tenants in commercial space going forward from the time of an ordinance. Energy and cost savings would accrue to landlords or tenants.

Based on our conservative forecast for the addition of new commercial buildings in Tucson, we build this analysis off of a projected 1 million additional square feet/year through 2020.

In conjunction with this measure, the City and TEP should create an aggressive direct load control system outreach and education program to all commercial energy tenants and landlords with the goal of having 10% of the total existing commercial square footage in the City being served with direct load control systems two years after program implementation.

Has the Measure been implemented elsewhere and with what results:

The total number of time-of-use or other forms of smart meters deployed around the world today is approximately 80 million units. This number is expected to triple in the next three to four years.[5] In Europe, Italy and Sweden have managed a near-100% penetration level of smart meters through aggressive deployment strategies. About 13 million smart meters have been installed in the United States, representing a penetration level of about 9%. This number is expected to increase to 30 million by 2012 and reach 50 million by 2014-15.[6]

In the U.S., a study by the American Council for an Energy Efficient Economy (though addressing the residential sector) estimated that a similar 12% savings would be likely on an annual basis as a result of smart meter deployment and subsequent reductions in energy use they inspire.[7]

In Miami-Dade County FL, the "Energy Smart Miami" program is a smart grid partnership involving the city, GE, Cisco, the local utility, and Silver Spring data communications company. The program is designed to overhaul the city's electrical grid and includes deploying smart meters in every home and most businesses. [8]

In the U.K., where smart meter deployment is occurring rapidly, The Carbon Trust undertook smart metering trials and the results showed that smart energy meters, when combined with consumption data and energy-saving advice, gave potential energy-savings of 12%/year.[9] In a country with already high energy prices compared to the United States serving to drive energy-efficient behavior, this percent of added energy savings is significant.

San Diego Gas and Electric began installing its first batch (200,000) of smart meters in March of 2010. The utility reports that its research shows customers typically cut their energy consumption by at least 5-10% when they know how much they are using.[10]

Energy/Emission analysis:

Existing Buildings

The commercial and industrial sectors (excluding TEP's natural gas combustion to produce electricity) in Tucson were responsible for a combined 9,490,164 MMBtu of electricity consumption in 2008.[11] This converts to 2,781,407,971 kWh/year.

If ten percent of the existing Tucson commercial / industrial space achieved a 12% reduction in electricity use as a result of smart meter installation, the annual energy savings would total 33,376,895 kWh/year (2,781,407,971 kWh x .10 x.12).

We project that half of the meters could be installed in 2011, creating savings of perhaps 25% of a full year's potential, or ~8.34 million kWh for the year. The other half of meter installations would occur in 2012, so we estimate that 75% of the potential savings are achieved in 2012, or ~25.7 million kWh. The full 33.4 million kWh savings begin in 2013.

Accumulated savings to 2020 in existing buildings: 292 million kWh.

The meters are assumed to have a 20-year life. Over the lifetime of the meters, ~642.5 million kWh would be saved.

Greenhouse gas emission reductions associated with this amount of energy savings total 22,705 tCO_2e in 2012 and 30,274 tCO_2e/year (full implementation) from 2013 to 2020. Cumulative savings to 2020 total ~265,000 tCO_2e.

New Buildings

Smart meters would be required on all new commercial and industrial buildings starting in 2012.

We project the addition of 1 million square feet per year (2009 commercial development level), which is ~1% of the existing inventory that uses 2.78 billion kWh/year. Therefore, new buildings would have an energy usage of 27,814,079 kWh/year.

A 12% savings from behavior changes as a result of mandatory smart meter installation would save 3,337,689 kWh/year. Greenhouse gas emission reductions associated with this amount of energy savings total 3,027 tCO_2e.

Depending on the recovery of the commercial new construction market sector, future new construction could likely exceed 1 million square feet per year and projections can be made then of expected energy, cost, and GHG reduction.

Cumulative savings by 2020 amount to 180.24 million kWh. Greenhouse gas savings over the 2012-2020 period totals 81,739 tCO_2e.

Total Electricity Savings

Combining energy savings from the two program components produces 29 million kWh in 2012 and 36.7 million kWh in 2020. Through 2020, the savings amount to 330.4 million kWh

The kWh savings in 2012 translates to 25,705 tCO_2e and 2020 savings of 33,301 tCO_2e. Through-2020 savings total 401,112 tCO_2e.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141

GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	25,705 in 2012 and 33,301 in 2020

Economic analysis:

Commercial smart meters have costs in the $240 - $300 range.[12] For our purposes here, we will use the $450 cost figure to attempt to include all associated expenses beyond the meter itself. We recognize that meter prices may decline, but installation costs and sophistication factors may combine to keep prices stable.

Under the mandatory element of this measure, the cost of a smart meter would be borne by the developer/landlord and would be recoverable through lower energy costs (if owner-occupied or if tenants' utility costs are absorbed into lease payments) or higher rents (if tenants pay their own utility bills and receive direct benefit from the information provided through smart metering).

We assume that 200 commercial properties, covering 10% of the 103,000,000 square feet of existing commercial / industrial property in Tucson, participate and pay $450 each for a smart electricity meter. Total costs for the existing building meters would be $90,000. Regarding new buildings, we assume that twenty commercial / industrial smart meters are installed each of 9 years year at a cost of $9,000/year.

Energy savings per customer varies widely depending on the type of building and a customer's level of engagement and motivation. However, based on the 12% projected energy savings and electricity prices increasing from today's $0.087 commercial TEP summer rate at 2.4%/yr, commercial / industrial tenants would save ~$2.5 million in 2012, steadily increasing to ~$6.8 million in 2020, adding up to ~$44.7 million accumulated savings by 2020.[13]

If the measure continues to require installation of smart meters past 2020 in all new commercial buildings, businesses will have saved ~$252 million by 2040.

Net Economic Impact

The net savings of this measure:

In 2020:	$ 6.82 million
Through 2020:	$44.5 million
Lifetime of meters:	$252.27 million

The cost savings per tCO_2e saved:

In 2020:	$119
Through 2020:	$111
Lifetime of meters:	$143

Considering the economic multiplier of 1.5 applied to saved energy costs, the positive impact on the Tucson economy is projected to be:

In 2020:	$10.2 million
Through 2020:	$66.7 million
Lifetime of meters:	$378.4 million

Co-benefits:

Co-benefits of the deployment of smart meters include:

1) Evening out often lumpy consumer demand for electricity which creates the need for costly, surplus stand-by generating units
2) Improved accuracy in billing and the sharp reduction of estimation errors and potential overcharging of consumers
3) Improved accuracy in utility forecasting of energy demand at different times of day
4) More competitive local businesses as energy costs decline relative to businesses not capturing energy efficiencies

Equitability:

The deployment of smart meters would likely be considered a progressive measure. The energy savings for businesses occupying smart-metered commercial space and responding to price signals would likely have more value to small businesses rather than larger ones who enjoy more of a volume-based business model. In all cases, the cost of energy meters, if borne by the tenant (rather than a utility, as in some programs) would be recouped through cost savings as result of behavioral changes in energy use.

Potential unintended consequences:

The complexity of the most dynamically-priced billing made possible with smart meters will be more difficult for customers to calculate themselves. Customers would have to rely on whatever software or online application a utility provides for bill tracking via computer. Customers will also need to trust energy companies to protect their usage data, calculate bills properly, and to charge the correct price at all times based on demand.

There has also been some concern that smart meters create the potential for computer hackers to target meters and any connected appliance (home computers) for criminal or vandalism purposes.[14] Protection of privacy concerns are being addressed through the development of national standards for smart meters intended to prevent such hacking. In addition, rules preventing utilities from sharing time-of-use energy consumption data with third parties is also being proposed.

Endnotes

[1] Pima Association of Governments. http://pagnet.org/RegionalData/EconomicSnapshots/NonResidentialRealEstate/tabid/605/Default.aspx

[2] Picor. December 29, 2010. http://www.picor.com/randp/index.cfm

[3] Tucson Electric Power. http://www.tep.com/Green/Business/tou.aspe

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[5] “MDMS Expected to Grow in Step with AMI.” Renew Grid. December 2010.

[6] Ibid.

[7] GreenBiz.com. http://www.greenbiz.com/news/2010/07/01/smart-meters-alone-wont-reduce-energy-use-study-says?page=full

[8] “Google Partners with Eight Utilities in Smart Meter Projects to Track Energy Use Online.” http://www.greenbiz.com/print/25305

[9] Catalyst Commercial Services. http://www.catalyst-commercial.co.uk/energy_extras/smart_meters/

[10] Op cit. (4)

[11] Regional Greenhouse Gas Inventory. Pima Association of Governments. October 2010.

[12] The Oil Drum. http://www.theoildrum.com/node/5592

[13] TEP. http://www.tep.com/Business/Programs/PricingPlans/tariffs.asp.

[14] PhysOrg.com. http://www.physorg.com/news176703307.html

Measure: Residential PV (G2e)

Increase uptake of residential PV by 400 homes per year resulting in adding 200kW of residential rooftop solar annually.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	2,910 tCO_2e/yr. in 2012; 29,104 tCO_2e/yr. by 2020
Percentage of goal (2012):	0.3%
Percentage of goal (2020):	1.3%
Total annual average implementation costs:	$3.465 million per year
Entity that bears the costs of implementation:	Homeowners ($3.44 million/yr) and City of Tucson ($25,000/yr)
Savings per tCO_2e over life of program:	$72
Net annual savings:	$976 per home
Entity that realizes the financial return:	Ratepayer
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	Homeowner investments for GHG reduction directed away from other investments with higher savings potential

Background information:

Solar electric systems, or photovoltaic (PV), convert solar radiation into useful forms of energy. Solar resources are most abundant in the southwestern US, therefore making this location the most applicable for large-scale implementation.[1] Decentralized residential PV in Tucson provides homeowners with clean, renewable energy that helps offset their fossil fuel derived energy needs while utilizing the region's most abundant natural resource.

This fact is not going unrecognized. According to Rep. Gabrielle Giffords:

> "*In the first six months of 2010, nearly 1,100 homeowners installed residential solar systems with SunShare rebates from TEP. That is more residential solar systems than had been installed in the previous nine years in TEP's service area."* [2]

When coupled with energy conservation and energy efficiency, this distributed energy solution can lead to important GHG emission reductions, spur local businesses, and create jobs.

The major obstacle to such installations is the large capital investment of PV systems. To overcome this hurdle, the City of Berkeley designed and implemented a financing mechanism that allows the homeowner to add the cost of the system to their property tax bill. Therefore, PV owners spread the capital costs over 20 years, and the system's financing mechanism stays with the home in case of sale.

Property tax based financing has now gained traction and is commonly referred to as PACE (Property Assessed Clean Energy) financing. According to the Alliance to Save Energy:[3]

> "*PACE financing allows property owners to benefit from energy savings immediately while spreading the cost of improvements over a number of years. The PACE model addresses and overcomes challenges that both borrowers and lenders have identified in seeking to use traditional finance mechanisms to fund efficiency improvements.*"

However, the use of PACE systems has been temporarily suspended because the Federal Housing Financing Agency (FHFA) has stated that PACE financing mechanisms do not meet the Fanny Mae and Freddie Mac federal mortgage requirements.[4] Solutions to this problem are under development.

Residential PV systems now average approximately 5 kilowatts, will in Tucson produced 8,500 kWh/year and have a pre-incentive cost of approximately $28,000.[5] With existing rebates from the Federal government, the State of Arizona and Tucson Electric Power, the present cost to homeowners is approximately $8,600. Over its lifetime, these initial costs represent 90% of system ownership costs.[6]

Financing this cost remains a potential barrier for homeowners, and over the 10-year life of this measure from 2011-2020, it is likely that the existing rebates will end and the financing issue for homeowners will become a greater barrier. Private companies have developed system lease products that may solve the financing problem (and take on system ownership challenges such as system maintenance), but it is uncertain whether these models will work if/when rebates end, or work with existing Tucson rebates.[7] For example, the lease approach may not work together with the present TEP $10,000 rebate because of TEP's ownership of the Renewable Energy Credits associated with the system.

Description of Measure and Implementation Scenario:

The measure is a commitment by the City of Tucson to remove financing barriers such that 400 PV systems averaging 5 kilowatts and producing 8,500 kWh/yr are installed in Tucson each year from 2011-2020.

This will likely involve general regulatory approaches such as adopting a PACE system for use by Tucson citizens, plus specific remedies that may be required to address financing system shortfalls that are presently not predictable, such as City-provided low-interest loans, etc.

Whether or not additional financing is made available to property owners, this measure can be combined with the Residential Community Climate Challenge (Measure E14). As the Climate Challenge is a public education campaign, marketing of the financial and energy savings and financing options need to be made clear to potential participants.

Has the Measure been implemented elsewhere and with what results?

The City of Berkeley implemented a PACE-type system pilot program named Financing Initiative for Solar and Renewable Technology (FIRST) that is intended to assist homeowners with the capital costs of installing solar energy systems.[8] FIRST allows a citizen to borrow money from the City, which is then paid back over the life of the loan via increases in their property tax bills, and the City of Berkeley has produced an implementation guide for local governments.[9]

Berkeley's pilot can be considered a success. They targeted 40 homes an ended with 13 PV systems installed under the FIRST mechanism and more via home equity loans (due to the more favorable interest rates). According to the survey in their assessment, knowledge of and access to financing to overcome the capital costs of utilizing solar PV had significant influence in their participation.[4]

The City of Austin, Texas has a successful PV rebate program administered by its utility Austin Energy. Through March 2010, the rebates have facilitated more than 1000 "customer-owned" systems plus 128 commercial/municipal systems, totaling 4 MW of solar capacity. The present residential solar rebate is $2.50 per watt, limited to $15,000 per year and $50,000 per site.[10]

Energy/Emission analysis:

A 5 kilowatt PV system in Tucson can be expected to produce 8,500 kWh/year.[5] This will displace 8,500 kWh/year of electricity from TEP, which presently produces 856 grams of CO_2e per kWh (this ration will vary over time – this analysis assumes it does not change over the 20 year projected life of the PV system). Each system therefore is projected to reduce 146 tCO_2e.

The 4,000 systems installed 2011-2020 will, over their lifetimes, reduce emissions by ~582,000 tCO_2e.

Description	***Input***	***Notes***
Expected electricity production of a typical 5 kilowatt residential PV system in Tucson, AZ	8,500	kWh/year
COT electricity grid emissions factor	856	Grams CO_2e/kWh
Expected annual GHG savings per home per year	7.3	tCO_2e
Residential PV uptake		
Homes assumed to utilize increased incentives and install PV per year 2011-2020	400	
Resulting GHG mitigation potential over life of program	582,080	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline)[11]:	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	tCO_2e
2012 BAU GHG emissions projection:	7,000,000	tCO_2e
2020 BAU GHG emissions projection:	7,343,141	tCO_2e
GHG emissions reduction to meet 7% goal (2012):	1,921,251	tCO_2e

GHG emissions reduction to meet 7% goal (2020):	2,264,392	tCO_2e
Residential PV- Increased Uptake		
Contribution of G2d Residential PV in 2020:	29,104	tCO_2e
% Contribution of G2d Residential PV to 2020 annual goal:	1.3	%

Economic analysis:

This analysis is completed from the homeowner's and City's perspective.

Description	***Input***	***Notes***
Average home electricity use in Tucson	11,000	kWh
Annual electricity production from system	8,500	kWh
Electricity costs per kWh 2011-2020	\$0.08 to \$0.10	Current average residential rates, increasing 2.4%/yr
Capital cost of 5 kW PV system	\$28,000	
TEP Upfront Incentive	\$10,000	\$2/Watt
State rebate	\$1,000	
Federal rebate	\$8,400	30% of gross amount[12]
Homeowner net capital cost	\$8,600	

Measure Costs

We assume that administering the measure requires 0.25 FTE at the City, costing \$25,000 per year for 10 years. We have also assumed that the City can implement a program that reduces homeowner costs sufficiently, such as a PACE-like program, without involving the City in borrowing to create a low-interest loan fund or otherwise causing City use of funds for which there is a cost of money.

Homeowners will invest \$8,600 for 4000 PV systems over ten years = \$34.4 million.

Total costs: \$34.65 million

Measure Savings

Based on the above inputs, the total savings to a homeowner installing a 5 kWh PV system has a payback period of just over 11 years. Over its 20-year life, a system installed in 2011 is projected to save $17,197; a system installed in 2020 is projected to save $21,799.

The savings of a system installed in 2011 will pay back the $8,600 initial cost in early 2022, and then generate a net savings of $17,197 - $8,600 = $8,597.

However, if the homeowner financed the $8,600 at 6% interest over ten years (current minimum credit union rate for home equity loan), interest payments would total $2,857, reducing the net savings to $14,340 and extending the payback term to early in 2025. This example is offered to illustrate the need for better financing options than home equity or other forms of capital cost financing.

A system purchased without interest costs in 2011 for $8,600 is projected to achieve ***savings*** of $59 per tCO_2e reduction.

Measure's Net Economic Impact

Costs 2011-2020: $34.65 million
Benefits over life of program (2011-2039): $76.7 million
Net savings over life of program (2011-2039): $42.1 million

The program is projected to save $72 per tCO_2e reduction over its life.

The net economic impact is estimated as the savings from 4000 systems of an average of ~$19,500 per installed system = ~$76.7 million. Because these savings result from local economic activity by solar installers and possibly solar manufacturing operations, it is reasonable to apply the multiplier used in this analysis of 1.5 to reach a net economic impact over the lifetime of the systems as $115 million.

Co-benefits:

Installation of PV systems cushion owners from fossil fuel rate spikes and it is reported that energy efficiency upgrades increase home resale values.[13] Moreover, incentivizing accelerated uptake of clean technology can help spur the local economy and small businesses. It also helps in job creation based on the new demand for skilled and knowledgeable plumbers. Lastly, this Measure is synergetic with the Community Climate Challenge (Measure E14), and the two, among others, should be considered in concert.

Equitability:

Such systems are only impact those who participate in the program. Due to the capital costs involved, even after rebates, the measure is not income neutral.

Potential unintended consequences:

The primary unintended consequence could be direction (via the financing system plus rebates) of homeowner capital funds that reduce GHG emissions away from energy conservation or other investments that might achieve greater GHG savings per dollar invested.

Other potential unintended consequences include:

- The increased use of electricity due to the availability of lower cost energy;
- The GHG savings may not be permanent if the financing scheme or other aspects of the investment result in the system's removal prior to its useful life.
- The manufacture of PV systems using current fossil-fuel dominated energy sources creates more global GHGs than the systems save.

Endnotes:

Notes:

1. *TEP's financial analysis (NOTE 5) has outdated system costs and has a miscalculation relative to the federal rebate. Moreover, the simple payback methodology assumes that energy prices remain constant over the life of their analysis (ie, 27 years). This analysis included herein based on current pricing and increasing energy costs achieves a payback 2x faster than the TEP analysis.*

2. *TEP assumes the rights to the Renewable Energy Credits (RECs) for the 20-year life of a PV system that utilizes TEP's Up Front Incentive (UFI). These RECs help TEP meet their renewable energy goals set by the Arizona Corporation Commission.*

3. *All references retrieved October through December of 2010 unless otherwise noted.*

[1] http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10710.

[2] http://www.hillpundit.com/blogs/congress-blog/homeland-security/120505-solar-boom-underway-in-tucson-southern-arizona-rep-gabrielle-giffords.

[3] http://ase.org/sites/default/files/PACE_factsheet.pdf.

[4] See: pacefinancing.org.

[5] Based on a 1 December 2010 meeting with Tucson's Solar Energy Coordinator, Bruce Plenk, and arizonagoessolar.com.

[6] Sungevity website, "Solar Home Lease," at: http://www.sungevity.com/solar-lease.

[7] Solar system leases are offered by Sungevity, SunRun and Solar City. The Sungevity lease, for example, requires no down payment and allows the system lease to run over a ten-year period, during which the inverter is replaced free if it fails. Energy production performance is guaranteed. After year six, the homeowner has the option to purchase the system at fair market value; after expiration of the original 10-20 year lease period, the homeowner has the option to extend another five years. See: http://www.sungevity.com/solar-lease.

[8] Berkeley FIRST Initial Evaluation: http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Berkeley%20FIRST%20Initial%20%20Evaluation%20%20final%20(2).pdf.

[9] http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/Guide%20to%20Renewable%20Energy%20Financing%20Districts2009.pdf.

[10] See Austin Energy rebate website at: http://www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/Solar%20Rebates/index.htm.

[11] PAG Regional Greenhouse Gas Inventory- 2010.

[12] PV owners will have to pay income taxes on the federal rebate via a 1099 form.

[13] http://www.nrel.gov/docs/legosti/fy96/17459.pdf.

Measure: Increased Commercial Recycling (G4, G4a, G4b)

Build on the successes of the ARRA-funded voluntary commercial recycling initiative by aggressively promoting recycling to all City commercial waste disposal accounts (focused on cost savings) with a goal of recycling 25% of the materials presently sent to landfills by commercial accounts by 2020.

The City's Environmental Services Division has already experienced a 20% success rate in new, voluntary commercial recycling accounts following the initial ARRA outreach effort. Higher participation rates are expected as the program grows through 2012.[1]

Yet there is an even larger universe of commercial waste accounts that could be tapped for their recycling potential.

Emission reduction potential:	14,448 tCO_2e
Percentage of goal (2012):	.08%
Percentage of goal (2020):	.64%
Total annual average implementation costs:	
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e:	
Net annual savings:	
Entity that realizes the financial return:	Commercial recyclers, City of Tucson
Equitability (progressive/regressive, income/revenue neutral, etc):	Equity-neutral as the program would be voluntary
Potential unintended consequences:	Uncertainties due to consistency of voluntary behaviors

Background information:

According to U.S. Environmental Protection Agency (EPA) estimates, 48 million tons of carbon emissions were avoided through recycling practices in 2005. This is equivalent to the emissions produced by 36 million cars per year.

Using recycled materials in place of virgin materials is the primary source of reduced carbon emissions with differing impacts depending on the material and on its comparative effect if landfilled.

Another way that recycling reduces GHGs from waste is the diversion of organic materials that will decompose from landfills, where the decomposition under pressure results in methane releases (methane is 21-23 times more potent as a GHG than CO_2). For this reason, the EPA aims to get all major landfills in the US fitted with systems that capture the methane emissions and burn the methane for productive use which transforms it into CO_2. A methane recovery system was installed at the City's landfill, Los Reales, in 1999 that pipes the methane to TEP for energy production (estimated to be enough for 4,000 homes).[2]

Single-stream recycling, as practiced in Tucson, increases the tonnage of recyclables collected in a community by 50%,[3] a benefit Tucson has already experienced. Extending this opportunity to the commercial sector will gain greater volumes for the City's program, avoid more carbon emissions, and result in new savings to the commercial participants.

Status Quo / Business as Usual:

As indicated below, waste and recycling tonnage data show a considerable additional opportunity for capture of recyclable materials from commercial waste hauling accounts held by the City of Tucson.

Absent the type of aggressive outreach campaign proposed, progress towards enhanced commercial recycling would be much slower, opportunities for greenhouse gas reductions delayed, and cost-savings for Tucson businesses lost.

Description of Measure and Implementation Scenario:

The City's ARRA-funded voluntary commercial recycling initiative shows early promise. Of the initial 54 commercial accounts contacted and audited, 10 have converted to recycling. More of these 54 are expected to join as corporate approvals to participate are forthcoming.

This measures calls for the City to compile the first-year successes of the ARRA program, highlighting cost savings and emissions reductions, and extend the outreach to a larger segment of its commercial customer base.

The stretch-goal is to bring into the City's commercial recycling base additional businesses that would not have participated without access to cost-savings information generated and available through the City's ARRA program efforts.

The stretch goal for this measure is to capture 50% of the commercially generated waste that is able to be recycled. This can be accomplished with an aggressive outreach campaign by City Environmental Services Division staff using actual commercial savings generated by and reported through the current ARRA commercial recycling initiative.

Has the Measure been implemented elsewhere and with what results?

Commercial recycling programs have been in place nationwide for decades, achieving multiple benefits in the areas of meeting recycling goals, extending landfill life, reducing emissions from extraction of virgin materials, stimulating local businesses involved in recycled-content product manufacture, creation of local jobs, expanding the local tax base, etc

Energy/Emission analysis:

A recent study has determined that there is a 0.61 tCO_2e reduction for every outbound ton of material outbound from a materials recovery (recycling) facility.[4] The City's commercial recycling initiative estimated greenhouse gas reductions on the order of 3 million tCO_2e once 450 commercial waste generators were contacted and audited and a significant number of them begin recycling.

The City of Tucson currently has 3,338 commercial waste accounts without recycling and 661 commercial waste recycling accounts (presumably also having non-recyclable waste collected by the City. Thus there is a total of 4,999 commercial waste hauling accounts served by the CIty, 661 of them (13%) also participating in the City's recycling program.

Commercial recycling tonnage in November 2010 accounted for 10% of the City's total recovered tonnage.[5] The City's total commercial waste in a year recently amounted to 95,000 tons. The 661 commercial recycling accounts were responsible for the diversion of 4,000 tons of recyclable material from the City landfill. Using the Resource Recycling emissions/ton multiplier above, the 4,000 tons being recycled have lowered City emissions by 2,440 tCO_2e/yr.

This analysis assumes that only half of the commercial waste (95,000 tons) now being landfilled annually can be recycled, or 47,500 tons. This measure proposes aggressive outreach to the 3,338 non-recycling commercial accounts that results by 2020 in half of that potentially recyclable commercial waste (23,750 tons) to be diverted to the City's recycling program.

We assume that this occurs incrementally over the decade as the outreach and promotion campaign reaches more and more potential commercial recyclers. For the purposes of this analysis, we assume that 11% of the 23,750 tons (2,639 tons) recycling goal is achieved each year beginning in 2012.

Greenhouse gas savings per ton of recycled material is reported at 0.61 tCO_2e.

The 23,750 ton goal, if achieved, results in projected greenhouse gas savings in 2020 of 14,448 tCO_2e. Savings at the end of 2012 would be 1,608 tons tCO_2e.

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure (2011 – 2020):	14,448

Economic analysis:

There is almost no additional cost to the City to add commercial customers to its recycling program. Waste pick-up trucks must run in any event to pick up refuse from commercial accounts, and recycling trucks already run routes that could easily take them to new commercial recycling pick-ups. These already-incurred truck expenses represent about 75% of the cost of the City's overall waste and recycling collection programs.[6] We therefore assume that the City's costs of serving new commercial recycling accounts do not exceed the benefits, even though the City's revenues from collecting the materials declines.

This positive cost/benefit scenario is facilitated by the City accruing revenues from the sale of collected recyclable materials. The sale price is determined by global markets out of the City's control which have seen wild swings in the past two years and are very difficult to predict. We have left potential City revenues from increased recycled materials to sell out of the economic analysis, calculating only the savings to commercial businesses from greater recycling.

Commercial recyclers are not required by the City, who they are contracted to for hauling services, to report customer savings from recycling charges that are less expensive than waste hauling charges by about 46%.[7] Volumes differ by commercial account and from month-to-month, making precise calculations of dollars saved difficult to obtain. We have assumed that a commercial account will save

The City's net revenue from all recycling tonnages collected and sold was $154,576 for the same month. Based on this number we calculate a total net revenue for the year of $1.85 million. Commercial recyclable values, at 10% of this number, bring the City an estimated $185,000/year.

The City reports, as noted above, that its costs to collect recycled materials are not covered by the revenue collected from the sale of recycled material. So we assume that there will be some additional cost to the City to collect recyclables from new commercial accounts.

The City has had a long-standing commitment to increased recycling at all levels. This indicates that whatever the incremental cost of adding new commercial recycling accounts it would not be a barrier to implementation of this measure.

Co-benefits:

See "Has the Measure Been Implemented Elsewhere" (above).

Equitability:

There are no apparent equitability issues raised by additional businesses voluntarily agreeing to sign up for commercial recycling accounts.

Potential unintended consequences:

None identified.

Endnotes

[1] Communication with Fran LaSala, City of Tucson, January 2011.

[2] Arizona Department of Environmental Quality, "Los Reales Landfill," at: http://www.azdeq.gov/environ/waste/sps/download/tucson/losreales.pdf.

[3] Resource Recycling. December 2010.

[4] Resource Recycling. Op.cit.

[5] Recycle America Alliance – Tucson MRF, City of Tucson Contracted Revenue Share for the Month Ending 11/30/2010.

[6] LaSala. Op.cit.

[7] Based on averaging the difference between City of Tucson commercial recycling rates for a given volume of materials and refuse rates, using the rate schedule for “Front Load Collection Service Monthly Fees,” at: http://cms3.tucsonaz.gov/sites/default/files/esd/Commercial%20Refuse_Rate%20Schedule%281%29.pdf.

Measure: Time-of-Sale Residential Energy Efficiency Retrofits (G17)

Adopt a city ordinance that establishes a mandatory time-of-sale requirement that residential buildings being sold meet basic energy efficiency goals.

Emission reduction potential in 2020:	11,973 tCO_2e
Percentage of goal (2012):	0.5%
Percentage of goal (2020):	0.5%
Total annual average implementation costs 2011-2020:	$13.49 million
Entity that bears the costs of implementation:	Home sellers/buyers ($13.464 million) and City of Tucson ($25,000)
Cost/Savings resulting from 2020 investments per tCO_2e over 20-year investment life (239,456 tCO_2e:	Savings of $138 / tCO_2e
Net annual savings over 20-year investment life, investments made in 2020:	$17 million
Entity that realizes the financial return:	Home sellers/buyers
Equitability (progressive/regressive, income/revenue neutral, etc):	Cost caps on such a program can be tailored to the price range of buildings being sold to avoid regressive effects.
Potential unintended consequences:	Diversion of investments to sub-optimal projects regarding GHG savings

Notes:

The measure's financial impacts are based on the following assumptions:
- Investments of $2,000 per home resulting in 1650 kWh/yr. electricity savings.
- Measure is crafted to affect 6,000 homes/yr. through 2016, rising 500/yr. to 8,000/yr. by 2020.

During the implementation period 2012-2020:
- 59,000 homes would be affected by the program.
- Each home would save from $3,419 to $4,132 from the $2,000 investment
- The $118 million invested would have saved $38.7 million by end of 2020 and $226.2 million over the lifetime of the investments.

Background information:

One proven way municipalities can spur the installation of energy efficiency in existing homes is to require a minimum level of efficiency upgrades at the time of property transfer. One form this takes is an Energy Conservation Ordinance (ECO).

Such ordinances can apply at the time of sale of owner-occupied residential units, which this measure addresses. ECOs can also be applied to rental property landlords and a version of this is analyzed elsewhere in this report. Finally, an ECO can be designed to apply to the transfer of commercial properties as well, or be applied to major renovations as well as the time of sale of properties.

Funding for a residential ECO, or RECO, is typically provided by the seller and calculated as either a percentage of the sale price, a set spending cap per unit, or a per square foot rate. In addition, there may be a filing fee in the range of $15 to $50. Responsibility for implementation of the upgrades can be negotiated between the seller and buyer, with time allowed for the buyer to complete improvements after the time of sale.

The energy efficiency goals can be prescriptive, featuring a list of mandatory upgrades (low-flow shower heads, weatherstripping, water pipe insulation, duct seals, solar shades, etc.), generally with a not-to-exceed cost per building.

A second program design is the performance-based approach where a series of diagnostic tests are used to determine the quickest, least-cost retrofit measures that contribute to a prescribed energy efficiency goal for a building. Both approaches have been used successfully, most prominently in Berkeley, CA. This community has recently moved from a prescriptive to a performance-based model that is expected to deliver deeper efficiency gains over time.

There is a lack of information about the energy savings results for most current ECO programs because tracking the before and after energy use is not within the scope or budget of the ordinances. However, San Francisco reports an average energy efficiency increase of 15% from its RECO.[1]

Business-as-Usual:

A mandatory time-of-sale ordinance achieves in a more aggressive fashion what might otherwise take much more time to realize – the capture of increased energy savings and the addition of home value that are two important co-benefits of such a measure. In addition, greenhouse gas emission reductions would occur more slowly in the residential building sector absent a time-of–sale ordinance and the energy efficiency gains it stimulates.

Description of Measure and Implementation Scenario:

A Residential Energy Conservation Ordinance (RECO) is proposed that should be designed to require a performance-based energy efficiency retrofit up to $2,000 at the time of owner-occupied residential home resale.

We forecast that upon implementation of such an ordinance, it could conceivably apply in its first year to a minimum of 10,000 new and existing homes based on recent, historically-low reported monthly home sales in Tucson, averaged over a full year.[2]

However, to gain the most energy savings for the lowest price, and not to penalize those who have already achieved energy efficiency gains, we recommend excluding from this measure those homes that were built after 2000-2001 (timed to the effective date in Tucson of the International Energy Conservation Code updated that year). We also recommend excluding those homes built earlier than 2000 whose owners can demonstrate that energy efficient upgrades have already taken place.

All other homes offered for sale or undergoing substantial renovation would fall under the requirement for an energy performance-based retrofit designed specifically for Tucson homes and climate.

Finally, we recommend that this requirement have an expenditure cap of perhaps $400/home for low-income owners/buyers/sellers or an outright exclusion from the program. We recommend a low-income definition consistent with other City housing programs, such as the Environmental Services Low-income Assistance Program, which in 2010 defined low-income as ~$33,075 for a family of four.[3]

In sum, the homes not subject to the measure would be 1) new homes sold each year, 2) homes excluded by a seller-based low-income threshold, and 3) existing homes that have had energy efficiency upgrades made to them or were built to be energy-efficient.

We project this would lower the number of homes to which a time-of-sale requirement would apply to 6,000 homes in the initial year, rising to 8,000 in 2020 as the economy grows and the sales of existing homes increases beyond today's historically depressed levels.

The average spending cap, which can be scaled to the price of the home, and reflecting today's costs of energy efficiency upgrades, would be $2,000 per home. Ideally this limit would be annually adjusted to reflect inflation or deflation of the typical Tucson-area projects stimulated by the RECO ordinance.

The proposed performance-based RECO will, by definition, include a requirement for a pre-sale home energy audit and a post-implementation energy audit so that energy and cost savings can be tracked and used in program modifications as necessary in later years.

Until actual program data are available, we assume an energy savings potential of 15%/home as has been realized in the San Francisco RECO, with its $1,300 cap on investments required per home. Actual savings may well be higher if the cost cap selected in Tucson exceeds the $1,300 number in the San Francisco program.

We project that the program could be designed and implemented by the beginning of 2012.

Has the Measure been implemented elsewhere and with what results?

Berkeley, CA has had a mandatory energy efficiency retrofit program in place since 1987.[4] Its Residential Energy Conservation Ordinance (RECO) applies to all dwelling units: homes, residential areas of mixed-use buildings, tenants-in-common, condominiums, multi-family properties, live-work spaces and boarding houses (including the common areas/common systems) and must be complied with upon sale or transfer of property, or major renovation.

A general outline of upgrades required in the Berkeley program includes:

1) **Toilets** – 1.6 gal/flush, or flow reduction devices;

2) **Showerheads** – 3.0 gal/minute flow rate – available free from the utility district;

3) **Faucet Aerators** – 2.75 gal./minute flow rate for kitchens and bathrooms – available free from the utility district;

4) **Water Heater Blankets –** insulation wrap of R-12 value;

5) **Hot and Cold Water Piping** – Insulate the first two feet from the heater to R-3 value;

6) **Hot Water Piping in Pumped Re-circulating Heating Systems** – Insulate all pipes to R-3 value;

7) **Exterior Door Weatherstripping** – permanently affix weatherstripping and door sweeps or door shoes;

8) **Furnace Duct Work** – Seal duct joints and add insulation wrap to R-3 value;

9) **Fireplace Chimneys** – Must have dampers, doors or closures;

10) **Ceiling Insulation** – Insulate to R-30 value or greater; and

11) **Common Area Lighting (multi-unit buildings)** – Replace incandescent bulbs with compact fluorescent lamps (CFL) of at least 25 lumens.

There is a limit to the amount of money that homeowners must spend to meet upgrades under the Berkeley program. Homeowners need not spend more than: a) 0.75% of the final property sales price when a single structure of two housing units or less is sold; b) 0.75% of the final property sales price for each structure when a property with more than one structure of two housing units or less is sold; or c) $0.50 per square foot when any one structure with three or more housing units is sold.

All homes or apartment buildings with a combined value of $50,000 or more in renovations must demonstrate compliance with the energy efficiency regulations by being inspected by and filing a certificate of compliance with the City of Berkeley. Compliance is the responsibility of the building permit applicant, which in most cases is the property owner.

Since its inception, an estimated 10,000 residential units have been affected by Berkeley's RECO. The ordinance is reported to have played a role in a 14% reduction in residential natural gas use over the 2000 –2010 period.[5]

However, the City also reports that, "Because energy savings from RECO are not currently measured or verified, it is impossible to know exactly what role RECO is playing to save energy in our community."[6] Moving to a performance-based, audit-driven RECO is intended to correct this problem.

Another time-of-sale energy efficiency retrofit program has been in place in **San Francisco CA** since 1982. Under this program, owners of residential property who wish to sell their property must obtain a valid energy inspection, install certain energy (since 1991) and water conservation devices or materials and then obtain a certificate of compliance.[7]

All of this must occur prior to transfer of title of any residential buildings as specified in the ordinance, and the seller must provide a copy of the compliance certificate to the buyer prior to title transfer.

The maximum amount to be spent depends upon when the decision is made to comply, as well as the number of units in a building. In the case of 1 or 2 family dwellings and individual condominiums and co-op units when complying as an entire building, the maximum expenditure is $1,300.

In the case of buildings containing 3 units or more (including condominiums), the owner can choose to comply before selling a property and the maximum expenditure will be 1% of the assessed value of the building. If a seller chooses to comply as a result of a pending sale, the maximum expenditure will be 1% of the purchase price as stated in the real estate sales contract.

The $1,300 limitation applies ONLY to 1 and 2 family dwellings and condominium and co-op units.

Energy/Emission analysis:

The latest statistics from the Tucson Association of Realtors Multiple Listing Service indicate a median sale price for Tucson homes in December 2010 of $139,500.[8] The average sale price during this period was $186,399. There were 907 unit sales in December 2010, a 13% increase from November and a 2% increase from December 2009. Over the course of a year, this translates to approximately 11,000 home sales.

We assume that between 6,000 and 8,000 eligible homes (see proposed exclusions in the implementation scenario) will be sold in Tucson each year once program implementation is underway. We assume the number of eligible homes remains at 6,000/year from 2012 through 2016, then increases 500 per year to 8,000 in 2020.

Using the savings realized under San Francisco's RECO program, we project a similar 15% energy savings per year per residence. The average residential electricity usage in Tucson is reported by TEP to be 11,000 kWh/year. A 15% savings per RECO-affected home would result in an average reduction of 1,650 kWh/year.

Each year that 6,000 homes are brought under the ordinance at the above savings/home, overall energy savings would total 6,000 x 1,650 kWh = 9,900,000 kWh/yr. For the total of 8,000 participating homes in 2020, 13,200,000 kWh/yr. would be saved.

Greenhouse gas emission reductions realized in the year 2020 would amount to 11,972 tCO_2e. Total emissions saved during the 2012-2020 period equals: 8,980 tons/year 2012 – 2016, and 11,972 tons/year by 2020.

We assume the investments have a 20-year life.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	11,973

Economic analysis:

Measure Costs

We assume that the investments caused by Tucson's RECO average the full $2,000 average cap level. Electricity prices start at $0.08/kWh in 2011 and increase 2.4%/yr.

The measure's costs to the projected 59,000 homeowners are shown in Table 1 below.

We also assume that the energy efficiency investments would not be made otherwise.

City of Tucson administration of the measure is estimated at 0.25 FTE/yr. at $100,000 per FTE for 9 years = $225,000.

Total investment: $118 million + $225,000 = $118,225,000.

Measure Savings

The estimated electric bill savings stimulated by Tucson's RECO range from $3,418 to $4,132, reflecting the steadily increasing prices of electricity saved. For simplicity, we have assumed that all savings are electrical, but in reality some savings will be natural gas and water consumption savings.

Table 1: Financial Analysis

Year	$ Invested (millions)	Yearly Savings (millions)*	$ Saved Over 20-yr Life Per House
2012	$12.00	$ 0.41	$3,418
2013	12.00	1.25	3,500
2014	12.00	2.13	3,584
2015	12.00	3.05	3,670
2016	12.00	4.01	3,758
2017	13.00	5.06	3,849
2018	14.00	6.23	3,941
2019	15.00	7.54	4,036
2020	16.00	8.99	4,132
2020 Total	$118.00	$38.67	$226.2 million all houses**

* Assumes retrofitted homes average 6 months of savings in first year of retrofit
** Total savings of the 59,000 dwellings affected through 2020, during years 2012-2040

Net Economic Impact

The net economic impact over the 20-year lifetime of the RECO-stimulated investments in 59,000 dwellings:

Measure Costs:	$118.225 million
Measure Savings:	$226.200 million over lifetime of investments
Net Savings:	$107.977 million

We use the 1.5 multiplier applied to energy cost savings by Tucson citizens to estimate the net positive impact on the City of Tucson economy of this measure as $162 million from 2012-2040.

Co-benefits:

There are multiple co-benefits that accompany the immediate energy and cost savings that flow from energy efficiency retrofits to currently energy-inefficient residential homes in Tucson. These co-benefits include:

1. An increase in home comfort as cooling and heating systems deliver more of their intended benefits to the conditioned space.

2. Likely delay in utility need to build new power plants thus minimizing rate increases owing to new capacity additions.

3. Increased adaptive capacity to temperature extremes expected as long-term climate warms in the southwest.

4. An increase in property resale values as energy efficiency gets built into a home.

Equitability:

The RECO initiative should be designed with exceptions and cost limits to keep from imposing regressive requirements on transactions of homes among low-income populations or on those who have already made significant energy efficiency investments in their property since its construction or purchase.

Potential unintended consequences:

Energy efficiency upgrades are arguably the most difficult to research since they cover a host of potential measures rather than one discrete technology. A package of energy efficiency upgrades for one home could be vastly different from those recommended for another home, so it is more difficult for property owners to compare quality of service with one another.

Since the recommended upgrades will vary widely with each property, there is no way to compare one's upgrades with those of peers. The only measurable evidence of the benefits of energy efficiency upgrades is in reduced utility bills, and this is not a comprehensive measure as many of the benefits fall within the realm of improved indoor air quality. Thus, there may be some unexpected skepticism over potential benefits along with unmet expectations if promised savings do not materialize.

Other potential unintended consequences include the potential that investments to meet the City's energy efficiency requirements are not the optimal investment for that home to reduce carbon emissions. Whether this occurs or not depends on how well the City's performance requirements are crafted regarding savings of GHGs.

Endnotes

[1] Residential Energy Conservation Ordinance Factsheet. http://www.ecoleader.org/assets/downloads/RECO/RECO_factsheet.pdf.

[2] *Arizona Daily Star*. January 11, 2010. http://azstarnet.com/real-estate/article_0c10d5a1-6af1-5ff8-829f-ea12f40d415e.html.

[3] City of Tucson Environmental Services, at: http://cms3.tucsonaz.gov/sites/default/files/esd/ES2010%20EformREVa.pdf.

[4] Berkeley Energy Commission. March 24, 2010. Item 4. http://www.ci.berkeley.ca.us/uploadedFiles/Planning_and_Development/Level_3_-_Commissions/Commission_for_Energy/ESD2010-03-24_CompletePacket.pdf.

[5] Ibid.

[6] Ibid.

[7] The Residential Energy Conservation Ordinance. San Francisco, CA. http://www.recaonline.com/docs/arc/arc2008/PointofSale_SanFranCA.pdf.

[8] *Arizona Daily Star*. op.cit.

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Measure: Mandatory C&D Recycling (G9)

Mandate a construction and demolition recycling diversion rate above the assumed local rate of 50% to one of the following:

- 80%
- 100%

Both mandate scenarios will be analyzed.

COT ARRA RFP Summary:

Emission reduction potential:	5,557 tCO_2e (100% diversion, 2020)
Percentage of goal (2012):	0.23%
Percentage of goal (2020):	0.25%
Total annual average implementation costs:	Not analyzed
Entity that bears the costs of implementation:	Developers
Cost/Savings per tCO_2e:	Not analyzed
Net annual savings:	Not analyzed
Entity that realizes the financial return:	Not analyzed
Equitability (progressive/regressive, income/revenue neutral, etc):	NA
Potential unintended consequences:	None identified

Background information:

Tucson construction and demolition (C&D) debris are currently diverted from one of the City's 25 landfills to recycling centers at an assumed rate of 50%.[1] [2] In the City of Tucson's fiscal year 2006-2007, nearly 1.65 million tons of municipal solid waste was generated.[3] C&D are assumed to make up 20% of the total waste stream based on EPA averages. The EPA estimates that approximately 25% of total solid waste is attributable to C&D.[4] Due to the significant reduction in local construction activity, WA assumes that waste streams from C&D activities have dropped to 50% of their 2006 values.

Tucson City Code 29 ARTICLE IX mandates landfill owners manage their landfill gas (LFG).[5] Methane from, for example, the Los Reales Landfill is piped over 3 miles to a co-fire power generation station resulting in enough energy to power 2,500 typical Tucson homes.[6] This power generation is offsetting either coal-based or gas-based power generation. Therefore, the exact science and math behind the emission reductions from any diversion of solid waste varies depending on the power source the methane is displacing. The upshot of Tucson's LFG management code is a lowering of, in most cases, emission reductions from an increase in waste recycling (there are some instances where the emissions actually rise depending on the type of debris).

Fortunately, the EPA has emission factors for different classes of debris based on how the waste disposed. The typical emission factor for C&D waste that is disposed of in a landfill with energy recovery (eg, LFG management) is 0.04 tCO_2e per short ton of waste.[7]

Description of Measure and Implementation Scenario:

The City of Tucson shall mandate a construction and demolition recycling diversion rate of 80% or 100% commencing in 2011. Both scenarios will be analyzed below.

Given the waste streams and assumptions reported above, WA projects total 2010 C&D debris for Tucson at just over 206,000 tons and a growth rate of 3% annually. It is very likely that the diversion rate for this waste is already near 50%, leaving the mandate to cover the balance.

Business As Usual:

As stated above, business as usual for C&D recycling in the Tucson area is assumed to be 50%. Under a business as usual scenario, management of C&D waste streams will continue to hold at approximately 50% through 2020.

Has the Measure been implemented elsewhere and with what results?:

The California government has a useful website, CalRecycle, that specifically addresses construction and demolition debris recycling, including a tools section for local governments.[8] The first step in the local government guide is to “know your waste stream.”

The City of Dublin, CA requires a C&D waste bond be posted prior to commencement of any project over $100,000. The bond amount is based on the estimated amount of waste to be generated and mandates that 100% of asphalt and concrete and 50% of all other waste generated is recycled.[9]

Energy/Emission analysis:

Starting with a C&D waste stream of over 206,000 tons in 2010 and increasing at 3% per year, the 2020 C&D total debris tonnage is nearly 278,000. The waste diverted with an 80% mandate, assuming 50% is already being recycled, is over 83,000 tons. With a 100% diversion mandate, the total tonnage being recycled in 2020 is projected to be nearly 139,000. The typical emission factor for C&D waste stream materials is 0.04.

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[10]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Mandatory C&D Recycling- 80% Mandate		
Contribution of G9 Mandatory C&D Recycling (in 2020 assuming 80% mandate):	3,334	tCO_2e
2020 Contribution of G9 Mandatory C&D Recycling (assuming 80% mandate):	0.15	%
Mandatory C&D Recycling- 100% Mandate		
Contribution of G9 Mandatory C&D Recycling (in 2020 assuming 100% mandate):	5,557	tCO_2e
2020 Contribution of G9 Mandatory C&D Recycling (assuming 100% mandate):	0.25	%

Economic analysis:

At the privately owned Speedway Recycling and Landfill Facility, owned by Fairfax Companies, the costs per ton of construction debris and that of recyclables are the same (currently $28 / ton).[11] Therefore, additional cost per tCO_2e is $0.00.

- ***Cost*** per tCO_2e = ***$ 0.00 / tCO_2e***

The barrier to C&D diversion rates increasing from the above industry norm of 50% more than likely has to do aversion to job-site sorting.

Co-benefits:

The EPA has listed other benefits of recycling that is applicable to C&D waste:

- Reducing pollution and conserving natural resources.
- Saving energy by reducing the need to extract and process “virgin” raw materials to manufacture new products.
- Stimulating the development of greener technologies.
- Avoiding the cost and land of waste disposal in landfills and incinerators.

This analysis doesn’t assume that the mandate reduces the amount of virgin materials used on the projects that create the waste stream. However, the conservation of natural resources and energy associated with virgin materials are those upstream from the waste diverted as a result of the analyzed mandates.

Equitability:

There are no apparent equitability issues.

Potential unintended consequences:

None identified.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

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[1] The assumed diversion rate of 50% was obtained from information contained on the City of Tucson Measure Matrix transmitted to Westmoreland Associates October 1, 2010.

[2] The 50% diversion rate is consistent with national averages: http://www.epa.gov/epawaste/conserve/rrr/imr/cdm/pubs/cd-meas.pdf

[3] This includes the Office of Conservation and Sustainable Development's data: http://www.tucsonaz.gov/ocsd/docs/CMS1_032885.pdf and an additional 50,000 tons for inert C&D waste disposal that was excluded from the research. For the 50,000 tons, the data can be found at: http://www.pagnet.org/documents/Water/PC208/Ch6_Apr06.pdf.

[4] http://www.wbdg.org/resources/cwmgmt.php

[5] http://cms3.tucsonaz.gov/sites/default/files/esd/landfillord.pdf

[6] http://www.tucsonelectric.com/Green/Services/methanegas.asp

[7] http://www.epa.gov/climatechange/wycd/waste/measureghg.html

[8] (www.calrecycle.ca.gov/Condemo/Tools)

[9] http://ca-dublin.civicplus.com/index.aspx?NID=661

[10] PAG Regional Greenhouse Gas Inventory- 2010

[11] http://www.thefairfaxcompanies.com/includes/pdfs/Fairfax_Brochure.pdf

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Measure: Non-residential Water Conservation (G23)

The measure calls for Tucson Water to create water conservation rates for non-residential customers and take other actions to reduce non-residential water use 10% per capita by 2020. A secondary strategy to consider is a partnership to reduce the carbon-emissions intensity of Tucson's water system 10% by 2020 (not analyzed).

Emission reduction potential by 2020:	4,056 tCO_2e / yr.
Percentage of goal (2012):	NA
Percentage of goal (2020):	0.18%
Total annual average implementation costs:	$0
Entity that bears the costs of implementation:	City of Tucson businesses
Cost/Savings per tCO_2e:	Savings $ / tCO2e are not estimated
Net annual savings:	Not estimated
Entity that realizes the financial return:	Tucson businesses
Equitability (progressive/regressive, income/revenue neutral, etc):	Progressive because overall City water rates likely to be less than otherwise
Potential unintended consequences:	Possible diminishment of Tucson commercial site and overall attractiveness

Background information:

Potable water treatment and distribution requires energy and generates GHG emissions. The Pima County GHG Inventory for 2008 reported that the City's GHGs associated with providing potable water to its residents caused ~115,000 tCO_2e in 2008 (23% from natural gas consumption and 77% from electricity) – a 10% increase from 2000 though a 3% drop from 2007. Water reclamation added 15,000 tCO_2e, bringing the water-related total to ~129,000 tCO_2e.[1]

Water demand is 56% residential, 19% multi-family and 25% commercial / industrial.[2]

The City's single-family / duplex / triplex residential water rates (adopted 2010) are designed to discourage excessive consumption by the use of an increasing block rates. Water consumption per month greater than 30 Ccf (748 gallons) at $8.14/Ccf is more than five times the $1.54/Ccf rate of the first 15 Ccf ($1.54), and consumption above 45 Ccf at the rate of $11.13/Ccf is more than seven times the rate of the first 15 Ccf.

More than 80% of Tucson's residential customers use less than 15 Ccf/month. The rate structure is designed to send a conservation message: "Use more water, pay more; use less water, pay less."[3]

Water users also pay a flat "Conservation charge" of $0.05 per Ccf to support the City's water conservation programs.

However, the increasing block rate has not been applied to non-residential users, who pay less than all residential blocks but the first 15 Ccf:

Mobile home parks with submeters:	$1.80
Industrial:	2.02
Commercial:	2.20
Multi-family:	2.29
Construction water:	2.47

These categories of water users pay a summer surcharge of $0.95/Ccf in Tier 1 and $0.25/Ccf in Tier 2.[4]

Tucson Water's "WaterSmart" program for businesses encourages water conservation with educational materials, tools, incentives, public recognition, case studies and direct customer support. The program recognizes levels of conservation performance via four award levels of Copper through Platinum, which is achieved by a 30% reduction in water use. Participants create a water management plan and budget.

In 2008, the City adopted its "Water Harvesting and Graywater" ordinances that require new commercial development to (1) utilize water harvesting practices to meet 50% of site landscape water requirements.[5]

Indicators and Goals

The Livable Tucson vision program of 1998 recommended an indicator regarding Natural Resources Conservation of reduced water use per capita.

In 2010 the City adopted its “2011-2015 Action Plan for Water Sustainability,” a cooperative project with Pima County. Though no specific water intensity or water volume reduction performance goals were adopted, a number of process goals were adopted to reduce water consumption in both residential and non-residential situations:

- Comprehensive, Integrated Planning
  - Encourage sustainable urban forms
  - Direct growth to suitable growth areas
  - Integrate land-use and water resources planning
  - Growth should pay for itself over time and be financially sustainable

- Demand Management
  - Increase the effectiveness of conservation programming through coordinated planning and evaluation.
  - Establish common water conservation goals and targeted methods.
  - Manage demand through design of the built environment.
  - Manage demand through changing behaviors.
  - Increase the use of rainwater and stormwater to reduce demands on potable supplies.

The Plan notes that “Establishing measurable water conservation goals was identified as a regional item. The City and the County have identified a benchmark study as an initial step to gather background information on measurable goals.”[6] The Plan does not mention water rates.

Status Quo / Business as Usual:

The flat non-residential water rates will continue to send a signal to non-residential water users that conservation is not a priority. Given the residential conservation rates that employees of commercial enterprises experience at home, the lack of conservation rates for their workplaces will be a noticeable contradiction that could undermine the desired effect of the conservation rates for residences (i.e. people may take the need for conservation less seriously if conservation rates don’t apply to all customers).

Regarding the reduction of carbon intensity of water operations, Tucson water would presumably participate in broad City-based carbon intensity reduction programs adopted. Reductions in carbon intensity would occur otherwise if:

(1) TEP becomes less carbon intensive;

(2) energy-using equipment like pumps or vehicles are upgraded to more energy efficient devices when replaced at end of their life;

(3) the business case for replacing energy-using devices with a more efficient device/system becomes compelling before the end-of-life; or

(4) the development and/or use of Tucson Water's own less-carbon-intensive energy supplies or generally less carbon-intensive energy sources become economically compelling (e.g. Tucson Water partners to own wind turbines to power its operations).

Description of Measure and Implementation Scenario:

The measure is designed to foster City actions that will reduce commercial sector water usage, starting with application of "conservation" water rates to commercial accounts, but including other measures necessary to achieve the goal of a 10% per capita reduction in commercial water use by 2020. The other measures could be the adoption of the Climate Wise business program that would foster business energy and water efficiency investments, or City business license/tax changes that would foster greater investment by businesses in water conservation, either using their own capital or energy-service performance contracts.

Establishment of conservation rates for non-residential water sources

Water saving investments typically have a strong return-on-investment because they save both energy and water. For example, water efficient washing machines generate strong savings of both energy and water costs (though energy savings are mostly dependent upon using cold water instead of warm or hot water, regardless of water efficiency). Water-using chillers are increasingly common as an energy-efficient way to cool buildings, and can be designed/installed with moderate, or maximum energy and water efficiency.

This measure assumes that City and NGO education programs, combined with marketing by energy/water savings businesses to business customers (including ESCOs) will help businesses maximize water savings, but that adoption of conservation-based water rates for commercial accounts is required to achieve the measure' goal.

Recommendation: Reduction of the carbon-intensity of Tucson Water's operations.

Westmoreland Associates recommends that the City investigate options for Tucson Water to reduce the carbon-intensity of its operations as a separate initiative. This is based on the PAG GHG inventory of the very energy intensive operations of Tucson Water (primarily due to Central Arizona project pumping energy).

Has the Measure been implemented elsewhere and with what results:

Municipal water utilities typically charge flat rates for water consumed by the commercial sector, but charge higher rates for higher water service capacities. For example, the City of Portland OR Water Bureau and the East Bay Municipal Utility District of the San Francisco Bay area both use extensive programs to support business water conservation, but rely on graduated service level charges to support efforts since water usage fees are flat.

Energy/Emission analysis:

Tucson Water's GHG footprint was ~129,000 tCO_2e in 2008. Their water services for non-residential customers were 25% of their total – meaning that if conservation rates reduced water use by non-residential customers 10% (roughly equivalent to a 10% per capita reduction at present levels of water consumption by the non-residential sector), a corresponding 2.5% reduction in carbon emissions could be expected.

We assume that non-residential water consumption will grow with Tucson's population, which is projected to grow 1.9%/year by PAG. The actual non-residential use is not likely to precisely track population growth, since the water intensity of Tucson future developments (such as industries or tourist/recreation attractions) could make a major difference.

Based upon a 1.9%/yr population growth rate to 2020, the commercial sector's share of water-based GHG savings at 10% per capita is projected to be 4,056 tCO_2e.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	4,056 tCO_2e

Economic analysis:

Westmoreland Associates recommends that the City collaborate with Tucson Water to accurately estimate the potential average return on investment from water conservation efforts made by businesses in response to conservation-based commercial water rates. This analysis assumes that the conservation rates cause businesses to invest and save water costs such that businesses achieve a breakeven point of no net increases in their water costs.

In other words, businesses invest in water conservation devices and/or behaviors that prevent paying more than their water charges are today, and no net savings or costs accrue to the businesses.

Co-benefits:

An important co-benefit could be extension of the City's cost-effective water supply to greater numbers of people and businesses, keeping rates lower for all customers.

Equitability:

If overall water rate increases are diminished by the reduced commercial water consumption, the measure is likely to have a progressive impact since lower income households likely pay more of their available income for water utilities than higher income households.

Potential unintended consequences:

If businesses respond to conservation water rates with behaviors that diminish Tucson's attractiveness to employers or visitors, an adverse economic impact could result. Westmoreland Associates projects that the measure's goal of a 10% reduction per capita in commercial water use does not require a diminishment of Tucson's attractiveness since examples of cost-effective water conservation exist throughout the country, including at golf courses and other heavily landscaped areas. Xeriscaping typically saves businesses on maintenance costs.

Endnotes

[1] Pima Association of Governments, “Regional Greenhouse Gas Inventory,” 2010, p. 35.

[2] City of Tucson and Pima County, “2011-2015 Action Plan for Water Sustainability,” p. 28.

[3] Tucson Water website, “Current Water Rate Schedules.”

[4] Tucson Water website, “Current Water Rate Schedules.”

[5] City of Tucson and Pima County, “2011-2015 Action Plan for Water Sustainability,” p. 29.

[6] City of Tucson and Pima County, “2011-2015 Action Plan for Water Sustainability,” p. 7.

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Measure: Commercial Thermal (G2c)

This measure analyzes mandating Solar Hot Water systems in for commercial buildings in Tucson. The analysis contemplates that commercial construction is substantially comprised of office and retail space. Calculations were completed assuming that all new construction water heaters are electric. Gas water heaters emit approximately 2/3 less CO_2e than their electric counterparts. Therefore, assuming the mandate replaces what would have been gas heaters, the already minute contribution of this measure would be further reduced.

Finally, due to the similarities with G2a Residential Thermal and the lack of material abatement potential, this analysis refers to that measure's write-up.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	3,600 tCO_2e
Percentage of goal (2012):	Negligible
Percentage of goal (2020):	0.16%
Total annual average implementation costs:	NA
Entity that bears the costs of implementation:	Developer
Cost/Savings per tCO_2e:	$138 / tCO_2e (assumed same as residential)
Net annual savings:	$162 / system (assumed same as residential)
Entity that realizes the financial return:	Ratepayer
Equitability (progressive/regressive, income/revenue neutral, etc):	Only effects participants
Potential unintended consequences:	Possible increased water usage

Background information:

Solar hot water heaters utilize the sun's radiance to augment, or sometimes completely offset, the need for conventional water heating systems, which rely on fossil fuels via electricity and/or natural gas.

Aggressively incentivizing such systems in areas with abundant solar resources (such as Tucson) can lead to quantifiable GHG emission reductions with a net cost savings to the property owners. Payback periods range from 5 – 20 years (with The Solar Store estimates ranging from 3-7 years).[1]

Systems for commercial use in this analysis are considered to be the same as residential (eg, solar hot water systems taking the pace of conventional 40- to 50-gallon electric water heaters). This, in fact, would be the case for office and retail space due to the low hot water demand of such buildings. Therefore, the solar hot water systems envisioned in this analysis are comprised of one to two storage tanks and either active or passive solar collectors.[2] For more information on the mechanics of the three primary solar collectors as well as descriptions on active versus passive systems, please see the DOE Energy Savers website under Note (2). As opposed to educating on the mechanics and science, this analysis seeks to quantify the practical implementation of wide-use solar hot water systems in Tucson's new commercial construction, focusing on systems and energy savings that are most applicable to the region. Fortunately, a unique non-profit, the Solar Rating and Certification Corporation (SRCC), exists that certifies solar energy products and provides regional average annual energy savings.[3]

Under current, local incentive structures, there is a wide range of net installed costs among systems ranging from $4,000 to $7,000 depending on the type of system. Savings to the property owner can total $270 annually per solar heater installed from reduced energy use.

Business as usual:

Absent increased incentives and/or mandating solar hot water systems, this cost- and energy-saving measure could continue to go underutilized in the region. However, given the low abatement potential under the stipulated assumptions, this may not be a measure that the Climate Change Advisory Committee wants to pursue.

Description of Measure and Implementation Scenario:

The carbon and economic analysis assumes new commercial construction includes a mandate to install a solar hot water system that meets the industry OG-300 standard (also a TEP rebate requirement).

Whether or not additional financing is made available to property owners, this measure can be combined with the Community Climate Challenge (Measure E14). As the Climate Challenge is a public education campaign, marketing of the financial and energy savings need to be made clear to potential participants.

Has the Measure been implemented elsewhere and with what results?:

As outlined in all of the solar initiatives in this report (ie, residential thermal, residential PV, commercial PV, and solar hot water for pools), many rebates and incentives exist. For example, the TEP rebates for systems under 400,000 kWh equivalents match that of the residential rebates.[4] However, commercial hot water systems are simply not widely adopted at nearly any level. According the 165 pages of data on solar systems in the TEP service area, there are a total of (2) commercial hot water systems that utilized TEP rebates.[5] These systems are both “reserved” (ie, not installed), and the sizes are 200,643 kWh and 50,734 kWh (Endnote 5: pages 117 and 118 after being sorted by “Technology”).

Energy/Emission analysis:

An SDHW system that meets the OG 300 standard can be expected to save 2,750 kWh of electricity per year.[6]

Description	***Input***	***Notes***
Expected annual electricity savings of a OG 3000 SDHW system in Tucson, AZ	2,750	kWh
COT electricity grid emissions factor	856	gCO_2e
Expected annual GHG savings per heater per year	2.4	tCO_2e
Commercial Construction Mandate		
Projected annual construction (sqft)	1,000,000	
Assumed QTY of buildings	50	
Assumed floors per building	3	
Square feet per FTE in commercial space	200	Average for retail and office space
Average hot water demand per FTE	10[7]	

Using the above inputs, one 40- to 50-gallon conventional hot water heater could be used to serve each floor of the commercial space. The daily load calculates out to approximately 330 gallons per day and that load is assumed to be uniformly spread throughout the day (7AM through 6PM). This totals approximately 150 new residential-sized solar hot water systems per year. Therefore, by 2020, the installed 1,500 systems would abate approximately 3,600 tCO_2e (or about 0.16% towards the 2020 goal).

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[8]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Residential Thermal- Increased Uptake via Incentives		
Contribution of G2d Residential Thermal (in 2020):	3,600	tCO_2e
2020 Contribution of G2d Residential Thermal:	0.16%	%

Economic analysis:

Description	***Input***	***Notes***
Annual electricity use for water heating per heater	2,925	kWh
Electricity costs per kWh	$0.08	Assumed to increase per this report's Energy Forecast
Capital cost of SDHW system	$7,000	
TEP Upfront Incentive (UFI)	$750	
TEP Performance Incentives (spread over 2 years)	$1,000	
Expected annual electricity savings	2,750	kWh
Federal rebate (30%)	$2,100	
State rebate (25%, max $1,000)	$1,000	
Cost after rebates	**$2,150**	
Life of analysis	20 years	

Based on the above inputs, the total savings to a property owner installing a solar hot water system has a net present value of $3,239 with a payback period under 10 years. It should be noted that installation in a commercial project may actually be more expensive that a home installation due to the length of plumbing to reach the roof required in a multi-story building.

- ***Savings*** per tCO_2e = ***$137.60 / tCO_2e***

Co-benefits:

Installation of solar hot water systems cushion ratepayers from fossil fuel rate spikes. Moreover, incentivizing accelerated uptake of clean technology can help spur the local economy and small businesses. It also helps in job creation based on the new demand for skilled and knowledgeable plumbers. Lastly, this Measure is synergetic with the Community Climate Challenge (Measure E14), and the two, among others, should be considered in concert.

Equitability:

Only effects participants.

Potential unintended consequences:

A potential negative unintended consequence is the increased use of water due to the availability of low cost hot water for domestic use.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.solarstore.com/index.php/faqs/1-solar-faqs/21-incentives-what-is-the-payback-time-for-a-solar-water-heater-

[2] http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12850

[3] Solar Rating and Certification Corporation: http://www.solar-rating.org/

[4] http://www.tep.com/Green/Business/Solar/spaceheating.asp

[5] http://arizonagoessolar.org/UtilityIncentives/TucsonElectricPower.aspx

[6] See TEP Green Energy- Solar Hot Water FAQs: http://www.tep.com/Green/Home/Solar/spaceheating.asp

[7] http://www.engineeringtoolbox.com/hot-water-consumption-person-d_91.html

[8] PAG Regional Greenhouse Gas Inventory- 2010

Measure: Solar Hot Water- Private and Public Pools (G10a/b)

Mandate new pool heaters (commercial and residential) use passive solar systems and that all government owned pools install solar hot water systems.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	1,305 tCO_2e (in 2020)
Percentage of goal (2012):	0.007%
Percentage of goal (2020):	0.06%
Total annual average implementation costs:	$120 (residential)
Entity that bears the costs of implementation:	Ratepayer
Cost/Savings per tCO_2e:	$267 / tCO_2e (residential)
Net annual savings:	$705
Entity that realizes the financial return:	Ratepayer
Equitability (progressive/regressive, income/revenue neutral, etc):	Only applicable to homeowners and commercial entities that can afford a pool
Potential unintended consequences:	Minimal

Background information:

Solar hot water mechanisms for pools utilize passive solar to meet, or augment, the heating needs via a renewable resource as opposed to more conventional gas heaters. The US DOE states that such heaters are:

> "*…cost competitive with both gas and heat pump pool heaters, and they have very low annual operating costs. Actually, solar pool heating is the most cost-effective use of solar energy in many climates.*"[1]

Although mandatory solar pool heaters will not result in material GHG reductions for the COT (as will be shown below), such a policy is a step in the right direction for utilizing the regions most abundant natural resource.

The system pumps pool water through the solar collector(s) that heat the water and then return the heated water to the pool. The use of such systems reduce or complete replace the need for gas heaters, therefore reducing the need for natural gas and the associated emissions.

The capital investment, which can be partially offset via local and federal rebates and incentives, is borne by the home/pool-owner. The payback period depends on the size of the system and the volume of heating that is demanded of it.

Business As Usual:

Under a business as usual scenario, pool-owner's that choose to heat their pools will do so with traditional natural gas heating equipment. This scenario also assumes that these pools are not covered during periods of nonuse.

Description of Measure and Implementation Scenario:

This analysis quantifies the potential GHG reductions from requiring that all new pool heaters (commercial and residential) use passive solar systems and that all government owned pools install solar hot water systems. Projected new construction pool permits are based on historical trends and the percentage of those that install a heating system is assumed to be 10% of that total.[2] There are also 9 public pools covered by this analysis; the City owns and operates 27 pools, but only 9 are heated year around.

Has the Measure been implemented elsewhere and with what results?:

Legislation for pool-only solar hot water systems could not be found. However, in 2011, California is requiring that all new pools are installed "solar ready" (Title 24- 114(b)). In a larger step towards solar hot water integration, Hawaii now requires all new home construction to include solar hot water systems (legislation SB644) (see Measure G2d for a discussion on Hawaii's legislation).

For public pool solar hot water implementation, El Paso, Texas has installed solar systems on 9 of their pools. They have reported a 40% savings on their energy bills and an average simple payback of 4 years.[3] [4]

Energy/Emission analysis:

The energy and economic analyses are completed over 20-years assuming the legislation takes effect 2011 (NOTE: the commencement year is essentially arbitrary other than assumed rate increases for natural gas from SW Gas as explained below).

Description	***Input***	***Notes***
RESIDENTIAL- Assumed annual pool construction	264.2	
RESIDENTIAL- Assumed % using heaters	10%	
COMMERCIAL- Assumed annual pool construction	4.2	
COMMERCIAL- Assumed % using heaters	100%	
RESIDENTIAL- GHG saved per pool per year	3	tCO_2e (see example calc below)
COMMERCIAL- GHG saved per pool per year	9	tCO_2e
PUBLIC- GHG saved per pool per year	13.5	Assumes 1,000 sqft pool surface, uncovered, and heated to 82º
RESIDETNIAL- Total GHG in 2020	801	tCO_2e
COMMERCIAL- Total GHG in 2020	382	tCO_2e
PUBLIC- Total GHG in 2020	122	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[5]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Mandatory Solar Hot Water Heating for New and Public Pools		
Contribution of G10a/b Pool Heating Measure (in 2020):	1,305	tCO_2e
2020 Contribution of G10a/b Pool Heating Measure:	0.06	%

To calculate the emissions savings per pool, the numbers for uncovered residential pools (assumed 200 sqft surface area), uncovered commercial pools (assumed 600 sqft surface area), and public pools (assumed 1,000 sqft surface area) were interpolated from a cost of $1,385 per year per 1,000 sqft of surface area based on $0.50 per therm.[6] The costs were updated based on $1.19 per therm for 2011 and increasing 2.3% annually. Based on these numbers, a residential pool is estimated to save 554 therms, a commercial 1662 therms, and a public 2470 therms, annually. Based on 5470 gCO_2e per therm, the savings are converted to 3, 9, and 13.5 tCO_2e for residential, commercial, and public pools, respectively.[7]

Economic analysis:

This analysis, per residential pool, assumes a 20-year life of the investment, a gas rate of $1.19 per therm in 2011 increasing 2.3% annually, a savings of 554 therms annually (residential) a capital cost (residential) of $2K, O&M costs of 10% of the capital.

- Based on this the cost ***savings*** equal: $ 14,106
- The ***savings*** per tCO_2e equal: $ 266.50 / tCO_2e

Using a capital cost of $5,000 for a commercial pool and the same inputs listed above, the cost ***savings*** and abatement ***savings*** for commercial pools are $43,517 and $268/$tCO_2e$. For the public pools the cost ***savings*** and abatement ***savings*** are, $55,590 and $206/$tCO_2e$ (assuming a $15,000 installation cost) per pool.

Co-benefits:

A potential co-benefit from a community standpoint is a small migration to using publically available heated pools due to the increased capital costs and possible reduction in heated residential pools. The government savings from the energy reductions at the public pools could be used to fund further mitigation projects.

Equitability:

This measure is only applicable to homeowners and commercial entities that can afford a pool.

Potential unintended consequences:

There may be some constituency backlash to the new legislation owing to the increased capital costs of solar hot water systems. It will be important to convey the very quick payback period for such an investment.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13230

[2] Based on information given in COT Measure Matrix titled and dated: GHG Measures Combined List_9.24.10- transmitted 10.1.10

[3] http://www.kvia.com/news/22936666/detail.html

[4] http://www.sunquestenergy.com/wp-content/uploads/Case-Study-City-El-Paso.pdf

[5] PAG Regional Greenhouse Gas Inventory- 2010

[6] http://www.swimmingpool.info/pool-heater.html

[7] http://carbon-calc.erg.berkeley.edu/documentation/CoolClimate_TA_methods_121709.pdf

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Measure: Enhanced LED Street Lighting Initiative (G3, E21, E21b)

Commit to a systematic replacement of all 8,222 residential streetlights that currently use low and high-pressure sodium (HPS) lamps with LED fixtures, providing equal or improved illumination at an attractive net savings over the estimated 15-year life of an LED fixture (vs. 5 years for an HPS lamp and 3 years for an LPS lamp).

Accomplish this by replacing 240 per year 2012-2020, and implementing a financial accounting system wherein the City uses the monies saved from these initial LED re-lampings for continued LED relampings of all existing streetlights.

The analysis below concerns only the replacement of 240 lamps per year 2012-2020, a total of 2,160.

COT Summary:

Emission reduction potential:	520 tCO_2e
Percentage of goal (2020):	.02%
Total annual average implementation costs:	$113,000
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e in 2020:	$306
Net annual savings in 2020:	$150,000
Entity that realizes the financial return:	City of Tucson
Equitability (progressive/regressive, income/revenue neutral, etc):	Life cycle savings will ultimately result in lower lighting expenditures in the COT budget
Potential unintended consequences:	Technology advances even more energy efficient than LEDs prior to the end of the LED design life

Note:

Over the 20-year lifetime of the 2,160 lamp replacements from 2012-2020 recommended by this measure, the City is projected to realize:

Savings of ~11,000 tCO_2e.
Savings to the City of ~$2.16 million.

Background information:

The City of Tucson currently maintains over 9,000 residential, grid-connected streetlights, some 850 now featuring LED fixtures. These streetlights use a mix of 4,447 high-pressure sodium lamps and 3,775 low-pressure sodium lamps. In 2008, City of Tucson streetlights were responsible for 5% of total City government greenhouse gas emissions.[1]

Light emitting diodes, or LEDs, are semiconductor diodes that emit light when conducting a current. LED fixtures consume less energy than traditional sources for the same amount of illumination. The design life of LEDs is generally many times that of traditional incandescent lamps.

By replacing City street lights (low and high pressure sodium vapor) with LED fixtures, the City could save a significant amount of money and reduce both energy consumption and greenhouse gas emissions. LED street lighting is a very popular energy efficiency, cost savings, and climate mitigation measure being taken by governments and industries across the country.

Compared to 2009, the City saved $2,848.42 in energy costs in November 2010 for the initial 850 lamps installed with ARRA funding. Over a year, the savings for these 850 streetlights should amount to $34,176. Through the 2020 period, energy savings from the 850 replaced lamps should total $341,760. The 850 lights represent about 10% of the inventory of streetlights still awaiting relamping.

Theoretical savings for all remaining 8,222 streetlights would be 10 times the $34,176 amount, or $341,176/year at 2010 electricity rates.

Description of Measure and Implementation Scenario:

The City should continue to invest in a streetlight lamp conversion initiative, with the goal of using savings from the initial 850 LED streetlight conversions funded under the 2009 Energy Efficiency and Conservation Block Grant to help finance the conversion.

Energy performance contracting services may also be needed if deployment of LED lamps is to occur within the 2020 time frame (see below).

As energy cost savings accrue month by month, the City could begin pooling these savings so that subsequent stages of LED relamping could be financed in part out of savings from previous relampings. The design of such a financing system would need to be worked out by the City, but in practice this should not be difficult.

Has the Measure been implemented elsewhere and with what result:

As of the beginning of 2010, 90 percent of the nation's lighting was in the form of high-pressure sodium, vapor lamps, while only 1 percent of the nation's streetlights employed LED lighting.[2] However, new municipal projects are beginning to come on line and significant inroads in LED re-lamping are being made.

In 2010, **Seattle City Light** installed 5,000 LED streetlights in residential neighborhoods and plans a total of 40,000 LED conversions during the next five years. City Light expects the LED streetlights to save $294,000 in the first year and $2.4 million per year once all 40,000 have been installed.[3]

The **City of Los Angeles**, CA is embarking on a major LED streetlight re-lamping project expected to take five years and replace 140,000 existing lamps with LED fixtures.[4] Projected annual energy and maintenance savings, post-retrofit, are projected at $10 million with annual energy savings of 68,640,000 kWh/year. Total project costs of $57 million give an expected payback of 7 years.[5]

Energy/Emission analysis:

Of the City's 8,222 residential streetlights eligible for conversion to LED, 4,447 are HPS lamps and 3,775 are LPS. 3306 are rated at 120W and 1,141 are rated at 175. (Actual lamp ratings are 100W and 150W before ballast power draw is added.)

Each high-pressure sodium lamp targeted for replacement is rated at either 110W or 150W. Factoring in added ballast power draw, actual power consumed per hour of use is 120W and 175W.

The HPS lamps (4,447) currently operate 10 hours/day. The 1141 175W HPS lamps thus consume 728,814 kWh/year. The 3306 120W HPS lamps consume 1,448,028 kWh/year. Combined, the HPS street lamps consume 2,176,842 kWh/yr

The remaining 3,775 LPS lamps for conversion to LED are rated at 110W. They consume 1,512,662 kWh/year.

Total energy consumption by the remaining HPS and LPS City street lights is 3,692,504 kWh/year.

At 53W/fixture, 8,222 LED lamps would consume 1,590,545 kWh/year.

Thus, total energy savings from relamping all 8,222 HPS and LPS street lights with 53W LED fixtures is 3,692,504 – 1,590,545 = 2,182,959 kWh/year, or 265.5 kWh/year per lamp.

Upon conversion of all remaining 8,222 non-LED street lights to LED fixtures, the greenhouse gas emissions reduced through the savings of 2,182,959 kWh/year amount to 1,980 tCO_2e/year.

This analysis assumes that the City replaces 2,160 lamps from 2012 to 2020 at the rate of 240 per year. Each LED lamp is assumed to save 265.5 kWh/yr.

Assuming an average of six months of savings in the first year of installation for 240 lamps, the GHG emissions savings would be small – 29 tCO_2e. For 2,160 lamps in place in 2020 and each saving 265.5 kWh/year, the GHG savings is projected to be ~520 tCO_2e.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,792
Contribution of this Measure:	520

Economic analysis:

Measure Benefits

The City pays \$0.07/kWh in 2011 for street lighting electricity.[6] Assuming rates increase 2.4%/yr. as projected by Westmoreland Associates, savings of this measure in 2021 at full deployment of the 2,160 LED lamps would be ~\$51,000. Accumulated savings from 2012-2020 is projected to be ~\$125,000. Savings over the 20-year lifetime of the lamps is projected at \$1.16 million.

An additional cost savings to the City occurs in avoided/deferred maintenance. An LED lasting 20 years would avoid the costs of replacing LPS lamps every three years. The City reports this savings potential at \$150/lamp per replacement, or \$450/lamp over a ten-year period.[7]

This analysis assumes that each LED, when installed, is credited for saving 6 replacements during its lifetime at \$150 each. Thus, the City's investment of ~\$113,000 each year results in maintenance savings of ~\$216,000 and electricity savings of 265.5 kWh at between \$0.7 and \$0.14/kWh.

It is reasonable for the City to invest the annual savings from electricity and maintenance into continual relamping until all 8,222 street lights have been replaced. Financial analysis of such a program should be performed when considering the source of capital for relamping.

Measure Costs

Estimated labor and materials for each HPS/LPS-LED replacement is $470. Each year for nine years, 240 lamps are replaced at ~$113,000/yr, or $1.015 million.

Net Economic Impact

In the year 2020:

Measure Benefits in 2020:	$263,000 (including lifetime maintenance savings)
Measure Costs in 2020:	$113,000
Net Savings in 2020:	$150,000

The savings per tCO2e in 2020: $306. Savings per tCO2e from 2012-2020: $487. Savings per per tCO2e over lifetime of the LEDs: $198.

By 2020, this measure will have cost the City ~$1.02 million. Lifetime maintenance savings of the LEDs is projected to be $1.94 million, and the City is saving $51,000/yr. in electricity costs. Total net savings: $2.089 million.

Applying an economic impact multiplier of 1.5 to the energy saved, the City economy would benefit:

In 2020:	$225,000
By 2020:	$1.7 million.
Lifetime of the LEDs:	$3.2 million.

Co-benefits:

Co-benefits of LED streetlight conversion include reduced City maintenance costs for periodic re-lamping as LED lamps outlast HPS and other incandescent lamps by a factor of at least 10 –15 years. The current operational life of white LED fixtures is 100,000 hours, which is 11 years of continuous operation (or 22 years of 50% operation.)[8]

Cost savings potential of avoided maintenance is calculated above. Because of their directional output, LEDs are also better at placing their light in a single direction than incandescent or fluorescent bulbs.[9] LED lights are more rugged and damage-resistant than compact fluorescents and incandescent bulbs. LED lights don't flicker.

Equitability:

The measure has a cost benefit to the entire community in that electricity savings from each deployment of LED fixtures will be used to invest in additional LED conversion until the full compliment of 9,072 City-owned/maintained residential streetlights are converted.

Potential unintended consequences:

One unintended consequence might include advances in more cost-effective and energy efficient streetlight technology becoming commercial before the end of the design life of the LED fixtures. There is also the issue of overall life-cycle environmental impacts of Led vs. alternative streetlight technology.

A University of Pittsburgh study on the subject recently concluded that LEDs contain "fewer harmful materials" than other lighting technologies, however it is more energy intensive.[10]

Thus, though LED fixtures are not as difficult a product to manage, do not contain mercury, and are not encased in glass, best practices still call for some form of responsible materials management/solid waste management plan to be in place to recapture as much as possible of the original metal and other materials in the LED fixture before disposal in a regulated disposal site.

Endnotes

[1] Regional Greenhouse Gas Inventory. Pima Association of Governments. October 2010.

[2] Pittsburgh Post-Gazette.com. January 18, 2010. http://www.post-gazette.com/pg/10018/1029038-53.stm.

[3] Powerlines. Seattle City Light. 2010. http://powerlines.seattle.gov/2010/07/07/seattle-city-light-begins-led-streetlight-rollout/.

[4] City of Los Angeles LED Street Lighting Case Study. http://www.mwcog.org/environment/streetlights/downloads/CCI%20Case%20Study%20Los%20Angeles%20LED%20Retrofit.pdf.

[5] Ibid.

[6] Communication with Mr. Ernie Encinas, Transportation Department, City of Tucson, November 15, 2010.

[7] Communication with Mr. Ernie Encinas, City of Tucson. January 2011.

[8] LightComp LED Corp. 2010. http://www.lc-led.com/articles/ledlights.html.

[9] NAHB Research Center. http://www.toolbase.org/Technology-Inventory/Electrical-Electronics/white-LED-lighting.

[10] Pittsburgh Post-Gazette. op. cit.

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Transportation Policy Options

- Voluntary Travel Carbon Offset Program (T5)
- Vehicle Maintenance (T10)
- Double Bike Lane Usage (T21)
- Anti-Idling Ordinance (T20)
- Transit-oriented Development Initiative (T6)
- ZEVsPHEVs (T7)
- Car Sharing Program (T19)
- Enhanced Energy Efficiency of the City of Tucson Vehicle Fleet (T3)
- Intersection Roundabouts (T13)
- Bike Share (T19)
- City of Tucson Telework Program (T2)

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Measure: Voluntary Travel Carbon Offset Program (T5)

Implement a city-specific carbon offset program that will increase investment capital available for carbon-reduction. The measure's goal is for 1% of citizen-based GHG emissions (about 45% of Tucson's total) to be offset in 2012, followed by 2% in 2013 and growing 1% of GHGs each year to 10% by 2021.

Relative to community engagement, implementation includes, but is not limited to, having a web-based site that enables community members to offset their carbon expenditures and kiosk in travel intensive hubs such as Tucson International Airport. Relative to delivering credible offsets, implementation includes engaging third-party organizations to generate the offsets.[1]

The potential percentage of the City's goal shown below is in italics to emphasize that the totals are not being counted in the total of the analyzed measures for GHG reductions because offsets are a financing mechanism, and counting offsets could therefore result in double counting.

Finally, we recognize that reaching the below abatement potential might be a 'stretch goal'. According to TEP's Annual Report, participation in their GreenWatts program is approximately 1.5% of their customer base. [2 & 3] Using this as a proxy for possible participation in an offset program, involvement could grow from from 1.5% to 10% over the course of the decade. If 10% of Tucson citizens participated in 2020, they would only need to offset less than ~5 tCO_2e to meet the below goals.

Emission reduction potential:	297,397 tCO_2e in 2020
Percentage of goal (2012):	*1.6%*
Percentage of goal (2020):	*13.1%*
Total annual average implementation costs:	$330,000
Entity that bears the costs of implementation:	City of Tucson or charitable donations
Cost/Savings per tCO_2e:	NA
Net annual savings:	NA
Entity that realizes the financial return:	NA
Equitability (progressive/regressive, income/revenue neutral, etc):	Positive: Offset projects can be designed to support marginalized communities
Potential unintended consequences:	Higher admin costs; loss of effectiveness due to poor offset investment choices; offsets have lower local economic multiplier than alternatives for the donated funds.

Background information:

There might not be a more discussed topic in climate change mitigation than the topic of offsetting. The science, quantification, economics, and morality of offsetting all need to be handled carefully and soundly.

Basically, an offset allows a person or entity to pay for a carbon reduction, which is universally measured in metric tonnes of CO_2 equivalents (tCO_2e – the primary measurement unit of this report).

There are two primary global markets for offsets: regulatory and voluntary. This report is concerned with the voluntary aspect of offsetting and only in a regional context for reasons discussed below.

The purchased reduction is intended to "offset" the emission of an equivalent ton of the purchaser. For an offset to be credible, it has to adhere to five distinct criteria. The offset has to be real, additional, verifiable, permanent, and enforceable.[4] These criteria include the concept that "but for" the offset money, the investment that reduces GHGs could not have been made.

The President of the Pew Center on Global Climate Change states simply and informatively that[5]:

> "*Offsets are crucial to achieving emissions reductions targets"*

When the offset is purchased, the offset retailer is under contract to implement a project meeting the above criteria. Options for offset projects range from reforestation to fuel switching to renewable energy generation to methane destruction to bike sharing.

Description of Measure and Implementation Scenario:

The City of Tucson implements a voluntary carbon offsetting mechanism that allows individuals to pay for local, real, additional, verifiable, permanent, and enforceable GHG mitigation projects affecting the City's emissions inventory.

It is assumed that the program is setup and administered through a third-party, which results in minimal costs to the City.

As the University of Arizona (UA) is on track to commence similar mitigation projects via the student-approved "green fee", it is advisable to coordinate any such efforts with UA to maximize abatement potential.

A significant portion of Tucson resident offsetting is likely to come from voluntary offsets of airline travel or ground-based out-of-Tucson, which is not currently a part of the City of Tucson's GHG inventory tracked by the Pima Association of Governments (PAG).

Therefore, this analysis concludes that offsets will not count towards the emissions reduction goals of the City of Tucson.

However, if the offsets are managed such that the funds are critical to emissions reduction projects going forward, the fund is likely to become a very important tool in support of emissions reductions.

The PAG emissions model does not account for land use changes; therefore, the City should not consider forestry projects with offset revenues if the sole intent is to reduce quantified emissions.

Important marketing of the program will occur at places associated with GHG emissions decisions, including TIA and private airports, fueling sites, sporting events, etc.

For example, if departing travelers at TIA are assumed to be 50% of the ~3.7 million passengers in 2009,[6] if only 2% of departures (92,500) chose to offset their roundtrip's approximately 2 tCO_2e (the average roundtrip distance per flight is assumed to be 2,068 miles[7] with associated emissions of 0.827 tCO_2e[8]), the offsets would total over 70,000 tCO_2e, which is more than 2% of citizens' estimated share in 2012.

Has the Measure been implemented elsewhere and with what results?:

Many US cities are leveraging offset funding to compliment their GHG mitigation. For example, San Francisco CA, Austin TX, and Denver CO are either implementing or working on programs analogous to the one envisioned for Tucson in this analysis.

According to the Department of the Environment, San Francisco's SF Carbon Fund[9]:

> *"…invests monies from activities that produce climate damaging greenhouse gas pollution (such as air travel) into local projects that reduce greenhouse gas pollution and support local economic development. All of the projects in the Fund take place within San Francisco's boundaries."*

In **San Francisco's** "Climate Passport" program, the cost per ton of CO_2e in San Francisco is $13.50 of which $1.50 is funneled back into the City's "Carbon Fund". The program is administered by an offset aggregator and retailer, 3Degrees[10]. Airport funds totaling $190K paid for the setup of the program[11]. Also, 3Degrees manages the kiosks[12]. A $12.00 portion of the revenue is used to purchase offsets form the Garcia River Forest Project. The other $1.50 is used by the City to establish offset-generating contracts with third-party project developers. Therefore, the only costs to the City are those to manage the contract with 3Degrees and the local project developers. We will assume this to be 0.5 FTE employee in the econ analysis.

Under the "Go Neutral" part of the **City of Austin's** Climate Protection Program, the City intends to "*Provide tools and resources for citizens, businesses, organizations, and visitors to measure and reduce their carbon footprint*.[13]" Their vision is that the program will include offsetting, but as of their 2010 annual report, implementation is forthcoming[14].

Denver's program, outlined in their Climate Action Plan, has been put on hold. [15 & 16]

Energy/Emission analysis:

We analyze this measure assuming that 1% of citizen-based emissions will be offset in 2012, an additional 1% each year (2% in 2013, 3% in 2014, etc.) to 10% of citizen-based emissions by 2021.

Citizen-based emissions are estimated at 45% of the PAG inventory total (27% is emitted by residential housing, to which we add one-half of transportation emissions that are 37%, reaching ~45%).

The yearly goals are the following in tCO_2e:

2012:	31,500	2017:	194,738
2013:	63,378	2018:	228,558
2014:	95,637	2019:	262,776
2015:	128,282	2020:	297,397
2016:	161,314	2021:	332,424

Total through 2021: 1,796,005

We assume that the offsets purchased through the measure are entirely used to finance GHG reduction projects in the City's inventory that would not otherwise happen. Since financial analysis of what would or would not happen without these funds has not been done, we are not including the reductions attributable to these offsets in the Climate Change Committee's plan to meet its 2020 goals.

Most all of the other GHG reduction measures have overall savings for the investors rather than costs per tCO_2e saved – so to count this measure along with the reductions sought through other measures would be potential double-counting.

Therefore, the chart below shows each tCO_2e offset resulting in an actual tCO_2e reduction, but the offsets are not included in the report's analysis of the cumulative effect of the various measures.

Climate Change Impact Summary in tCO_2e:

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline)[17]:	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Voluntary Travel Carbon Offset Program		
Contribution of T5 Voluntary Travel Carbon Offset Program (in 2020):	*297,397*	tCO_2e
2020 Contribution of T5 Voluntary Travel Carbon Offset Program:	13.1	%

Economic analysis:

Measure Costs

We assume each ~30,000 tCO_2e offset requires 0.6 FTE to administer the program, and that each FTE costs $100,000.

Administrative costs in 2012 are $60,000; in 2020 $600,000. Total administrative costs are $1.65 million over ten years, averaging $330,000/yr. In other words, the costs are about $2 per tCO_2e offset.

For comparison, the economic involvement of the City government appears to have been very low in the case of San Francisco. Airport funds were used to initiate the project, and their contractors (3Degrees et al) manage the kiosks and handle the carbon offset generation. Its cost is estimated at $13.50 / tCO_2e.

Measure Savings

We are not counting the offset investments as actual savings to avoid double counting.

However, the potential exists for the offset program to facilitate 1.8 million tCO_2e reductions in Tucson through 2021.

Net Economic Impact

This is not calculated since the net economic impact will primarily depend on the local multiplier of the offset expenditures on GHG reductions and program administration compared with the local multiplier of the expenditures of the offset money for other purposes.

Since most GHG reduction measures create long-term savings for the investors, the offset program could have a very positive economic impact if it is used to facilitate those investments in residential PV systems, etc.

Co-benefits:

Co-benefits include reduced pollution, spurring local business via mitigation projects, projects can be used to further local adaptation planning and/or to help reduce the urban heat island effect.

Equitability:

Offset mitigation projects can the geared towards assisting marginalized communities with the capital investments associated with energy conservation and energy efficiency.

Potential unintended consequences:

Negative unintended consequences include the following, though the risks are low of their occurrence:

- The offsets not meeting the above-mentioned five criteria for legitimacy, and the program loses credibility with the public and becomes a poor investment of administrative expenses. It is especially important that the offsets are invested in projects that would not have otherwise occurred.

- Administration costs are much higher than predicted, causing a reduction in the effectiveness of the offsets program at actually reducing Tucson emissions.

- The spending of the offset funds has a lower local economic impact multiplier than where the donor would have spent the funds otherwise.

Endnotes:

References Note: All references retrieved October through December of 2010 unless otherwise noted.

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[1] Conflict of Interest disclosure: Co-author of this analysis David Schaller is a co-founder of an existing local carbon-offset program, The Local Trust, which is a program of the Global Sports Alliance.

[2] http://www.tep.com/Green/Greenwatts/Docs/ACCAnnual2009.pdf

[3] http://www.faqs.org/sec-filings/100226/TUCSON-ELECTRIC-POWER-CO_10-K/#105

[4] World Resources Institute's *Outside the Cap: Opportunities and Limitations of Greenhouse Gas Offsets*. Available: http://pdf.wri.org/outside_the_cap.pdf

[5] Congressional Testimony of Eileen Claussen - *How to Design Legislation to Contain Cost and Minimize GHG Allowance Price Volatility*. Available: http://www.pewclimate.org/federal/congress/testimony/claussene/how-to-design-legislation

[6] http://www.flytucsonairport.com/includes/media/docs/CAFR_2009_final1.pdf

[7] http://www.bts.gov/publications/transportation_statistics_annual_report /2004/html/appendix_b/html/table_05_04.html

[8] Calculated at: http://www.nativeenergy.com/pages/travel_calculator/465.php

[9] http://www.sfenvironment.org/our_programs/topics.html?ssi=6&ti=85

[10] http://www.sfenvironment.org/downloads/library/sfe_sfo_climate_passport_faq.pdf

[11] http://calairportscouncil.org/articles/(SFO)_11_1_09_Carbon.pdf

[12] http://www.flysfo.com/web/page/about/news/pressrel/2009/sf0963.html

[13] http://www.ci.austin.tx.us/acpp/downloads/acpplan_overview.pdf

[14] http://www.ci.austin.tx.us/acpp/downloads/acpp_annual_2010.pdf

[15] http://www.greenprintdenver.org/docs/Greenprint_Council_Report_Rec3.pdf

[16] http://www.usatoday.com/travel/flights/2008-06-29-airport-checkin_N.htm

[17] PAG Regional Greenhouse Gas Inventory- 2010

Measure: Vehicle Maintenance and Behavior Education Program (T10)

This measure concerns a Vehicle Maintenance and Behavior Education Program (hereafter Program) to improve the fuel efficiency of vehicles registered in the City through fuel-efficiency education and tire-inflation inspection regulations.

The education component targets are the fuel efficiency and vehicle maintenance cost benefits of ensuring that vehicle tires are not under-inflated, engines are optimally working, and driving behaviors are adopted that improve fuel efficiency.

The regulations component targets the practices of professional vehicle maintenance businesses and fleet managers in order to ensure they include monitoring of fuel-saving conditions (particularly tire inflation) when vehicles are serviced.

Vehicle miles traveled (VMTs) in Tucson are estimated to be 93% gasoline-fueled and 7% diesel-fueled.This measure's goal is a 5% improvement of existing vehicles' fuel efficiency for 35% of the gasoline-powered vehicle miles traveled in Tucson. The measure would begin in 2011 and aim to maximize its fuel efficiency impacts to 35% of gasoline-fueled VMTs as soon as possible. .

Emission reduction potential 2020:	41,856 tCO_2e
Percentage of goal (2012):	NA
Percentage of goal (2020):	1.85%
Total annual average implementation costs:	$100,000
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e 2011-2020:	Savings $436/tCO2e
Net annual savings 2011-2020:	$16.8 million
Entity that realizes the financial return:	Vehicle owners
Equitability (progressive/regressive, income/revenue neutral, etc):	Likely neutral but could be progressive if fuel and maintenance savings accrue disproportionately to lower income households as expected
Potential unintended consequences:	Shift of citizen $$ expenditures from auto fuels and maintenance to other uses or savings

Background information:

Vehicles with under-inflated tires experience up to a 3.3% fuel efficiency penalty (based on each pound per square inch of under-inflation resulting in a 0.3% reduction). It is estimated that the average US vehicle has tires that are underinflated by 10-11 PSI.[1]

The State of California's Air Resources Board estimated in 2009 that 38% of vehicles in the state have "severely underinflated tires" at 6 PSI or more under full inflation, which is part of the rationale for its tire inflation regulations of 2010 (see below).[2]

Other vehicle maintenance techniques can also dramatically affect fuel efficiency, including repairing or replacing faulty oxygen sensors (40% effect), using the correct motor oil weight (1-2% effect) and optimal engine tuning (average 4% effect).[3]

Driving techniques alone can significantly affect fuel efficiency. The US government's Fuel Economy website estimates the efficiency differences of various techniques as follows:[4]

- Sensible rather than aggressive driving: 5-33%
- Observing speed limits: 7-23% (each 5 miles per hour over 60 increases the effective price per gallon of gasoline by 24 cents, assuming a pump cost of $2.87; other estimates are that for every 5 mph above 55, 10% of fuel economy is lost[5])
- Remove excess weight from vehicles: 1-2% for each 100 pounds
- Avoid excessive idling, use cruise control, and use overdrive gears: (no data)

So-called "hypermilers," who drive with a goal of maximizing fuel efficiency, as reported by many drivers of hybrids and recent vehicle models with clearly visible real-time fuel economy gauges, have obtained up to 62% higher than expected fuel use.[6]

Various opportunities exist for drivers to learn about the potential efficiencies from better maintenance and driving habits. None, however, are facilitated or required by the City of Tucson or State of Arizona at the present time – they require interest in the topic by the individual. Arizona's vehicle emissions programs periodically ensure that vehicles in urban areas are sufficiently tuned for maximum performance (low emissions translates into low fuel usage).

According to the State of Arizona's Environmental Quality Division, the emissions test initial failure rates in Pima County ranged from 10% to 12% over the three years 2007-2009. In 2009, vehicles built in the 1990s failed at rates ranging from 6-18% while vehicles built in the 2000s failed at less than 10%. Vehicles built in the 1980s represented 9% of tested vehicles but 20% of failures; 1990s vehicles represented 45%

of tests and 44% of failures; vehicles built in the 2000s represented 43% of tests but only 28% of failures.[7] These failure rates illustrate that potential exists to improve fuel efficiency by an educational program regarding the higher fuel costs and GHG emissions of driving un-tuned vehicles.

Status Quo/Business as Usual:

Information about the merits of fuel-efficient vehicle ownership is available on internet sites and in various print publications. However, given that the information has been available for many years and millions of gallons of fuel remains wasted, it cannot be expected that the waste will be solved without specific actions by the City.

An additional factor in reducing waste are technologies in newer vehicles that provide feedback to drivers on the fuel efficiency of their driving habits and/or tire inflation conditions. However, these systems will remain a small part of the overall vehicle inventory in the City for several years to come.

Description of Measure and Implementation Scenario:

The Program's goal can be stated two ways:

(1) An reduction of xx million gallons of gasoline annually from vehicle fuel usage in the City via vehicle maintenance and usage strategies, or

(2) An x% increase in fuel efficiency annually during yy% of VMTs through vehicle maintenance and usage strategies.

This measure uses the second approach, and is projected to save about four million gallons of gasoline per year when achieving 5% efficiency improvement for 35% of gasoline-fueled VMTs (93% of VMTs in Tucson).

The tire inflation regulation – that all tires will be inspected for inflation levels during any professional work on a vehicle and fixed as necessary – **is projected to comprise 70%** of the measure's effects. This projection is based on the assumption that the measure's tire inflation inspection regulation will cause 25% of vehicles to experience a 3% improvement in MPG because of inflating underinflated tires.

The remaining 30% of the emission reductions are projected to come through education and marketing the many reasons to ensure a vehicle is performing optimally, including the fact that tires and other components last longer, and that driving behavior adjustments can save drivers money, improve safety and lessen environmental impacts.

Specific data assumptions and projections are shown in Table 1. Vehicle miles traveled and related tCO2e emission projections for 2015 and 2020 were provided by PAG,[8] intervening years were extrapolated by Westmoreland Associates. The Program's projected effects reflect gasoline VMTs only (93% of total VMTs) since diesel usage is a very small part of the private vehicle sector targeted by the Program.

Table 1: Program Fuel Savings Assumptions and Projections

Year	Vehicle Miles Traveled (gasoline, in billions)	Gasoline Saved by Program (millions of gallons)	tCO2e Saved by Program (thousands)
2012	4.32	4.02	36.6
2013	4.41	4.09	37.2
2014	4.51	4.16	37.9
2015	4.60	4.24	38.5
2016	4.70	4.31	39.2
2017	4.80	4.38	39.8
2018	4.90	4.46	40.5
2019	5.00	4.53	41.2
2020	5.10	4.61	41.9
Totals	42.3	39.4	353.5

Assumptions:

Program achieves 5% MPG improvement over 35% of gasoline-powered vehicle miles traveled in Tucson starting in 2012.

The Program will combine education and regulations:

- Vehicle owners will learn about the multiple benefits of vehicle maintenance for improved fuel economy and reduced maintenance costs beginning with driver's education courses and including traditional media, social media, driver testing (including influencing the State of Arizona to include fuel economy improvement strategies in driver's license tests), vehicle registration procedures, vehicle sales and repair sites, and all other reasonable means.

- Vehicle repair and fleet management operations will be encouraged or required to perform low-cost vehicle fuel economy checks such as tire inflation levels as part of maintenance procedures.

Has the Measure been implemented elsewhere and with what results:

Research did not find any similar measures in US states or municipalities.

The **State of California's** tire inflation regulation, which took effect 1 September 2010, requires the state's automotive maintenance industry to check the tire inflation of every vehicle it services. The regulation was projected to eliminate 700,000 metric tons of GHGs by reducing the state's fuel consumption by 75 million gallons per year.[9]

The Portland, OR, Climate Action Plan (2009) includes an objective of increasing the average fuel efficiency of privately owned vehicles to 40 MPG by 2030 (and improving performance of the roadway system), but does not include a program to help drivers improve their existing vehicle fuel economy among the actions to be completed before 2012.[10]

Burlington, VT, includes "pump up your tires" among the ten ongoing behavior recommendations for what citizens can do in support of a Climate Action Plan, but Burlington does not have a program that supports vehicle maintenance or driving behaviors for higher fuel efficiency.[11]

The **City of Boulder, CO, Climate Action Plan** includes a strategy that "all programs and initiatives will be designed to reduce vehicles miles traveled (and) purchase more efficient vehicles," and its transportation programs include "improve fuel economy of the public and private fleets," but none of the nine policy recommendations include improving existing vehicles' fuel efficiency.

Boulder's primary adopted strategy is to "support the Transportation Division's programs that reduce vehicle miles traveled." The City conducts a periodic Travel Diary Survey to update information, especially of selected populations, regarding travel behaviors – this system could be adapted to help the City of Tucson understand the effectiveness of its Vehicle Maintenance and Behavior Education Program on driving habits.

Boulder's "GO Boulder" program (GO stands for Great Options) was created as a management program for the improvement of citizen transportation behaviors; it received a grant in 2009 to develop a "one less car" campaign that would help citizens reduce vehicle miles traveled.[12]

Energy/Emission analysis:

This analysis assumes the following for the ten years 2011-2020:

- An average of 4.38 million gallons of vehicle fuels are saved, based upon MPG improvements of 5% for 35% of vehicle miles traveled, starting in 2012.[13]
- Combustion of one gallon of gasoline results in 19.7 pounds of CO_2 emissions.[14]
- The gasoline gallons saved were not produced in the City of Tucson (in other words, the emissions involved in the fuel's production and distribution (upstream lifecycle) are not also saved from the City's GHG inventory).

Climate Change Impact Summary in tCO_2e

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	41,856

Economic analysis:

Measure Costs

The Program is estimated to cost $100,000 per year for part-time administration, educational tool development and regulatory development and administration. Costs would likely be borne by local governments and/or donors/partners.

It is reasonable to expect program funding would be possible through vehicle maintenance surcharges (for example, a 0.5% tax on vehicle maintenance services) and sales of educational materials.

It is possible that regulations supporting the Program's goal could increase consumer costs of vehicle maintenance, depending on the nature of the regulations and the ability of vehicle maintenance providers to absorb the additional tire inflation check/fix requirements into fixed prices for oil changes, tire changes, full-service fueling, or other services that might trigger checks for optimal fuel performance.

Measure Benefits

The Program's success would result in savings to consumers in two ways:

- Reduced fuel costs
- Reduced maintenance costs

Reduced fuel costs are estimated at $157.2 million over nine years, or about $17.5 million per year, based on the Westmoreland fuel price projections for Tucson.[15]

Reduced maintenance costs start with properly inflated tires. Studies show vehicle-installed tire pressure monitoring systems can extend tire life by 4,700 miles,[16] or, viewed another way, 10-11% under-inflation reduces tire life 18%.[17] These potential tire cost savings are not counted as financial benefits in this analysis, but could be substantial.

Net Economic Impact

Net fuel expenditure savings to Tucson citizens: $157.2 million less $1,000,000 Program costs over ten years (starting 2011) = $156.2 million.

The benefits to Tucson citizens per tCO_2e reduced is projected at $489 in 2020, and $446 over the Program's nine years.

Using the economic impact multiplier for savings, the net economic impact in 2020 is projected to be $30.6 million. Net economic impact over the life of the program is projected to be $234.2 million.

Co-benefits:

The Program's co-benefits could include the following:

- Reduced auto accidents and therefore lower insurance rates due to less aggressive driving and improved vehicle maintenance

- Less traffic congestion because of less aggressive driving habits.

- Reduced auto expenses from the extended life of vehicle components such as tires and other components of existing vehicles (for example, one fuel efficiency tip is the use of synthetic motor oil that has benefits aside from efficiency).

Equitability:

There is no definitive data to determine the equitability of the proposed Program; programmatic equitability would only be measurable by surveys of people affected after the Program's implementation. However, pre-implementation surveys could be used to refine the Program's focus and techniques to maximize benefits to lower income citizens.

The Program will possibly have a stronger effect on the vehicle maintenance and driving decisions of people for whom money and time are scarce, as they are more likely to neglect vehicle maintenance. The higher emissions testing failure rates of older vehicles indicate that older vehicles are more likely to not be optimally tuned for fuel efficiency.

All income levels are able to maintain tire inflation levels or adjust driving behaviors at next to zero cost. Lower income citizens who saved on both gasoline and maintenance costs (e.g. tire replacement costs) would be saving more of their disposable income than high income drivers, who may be more likely to perform maintenance without education or regulations in any case.

If the Program as proposed were expanded to include financial rebates to citizens for "eco-modifications" to existing vehicles,[18] those rebates could include an income-qualifier to ensure the rebates would primarily accrue to lower income households.

Potential unintended consequences:

If successful, the Program will reduce expenditures on total vehicle operations, especially fuel costs but also maintenance, which may have a positive effect on the Tucson economy, depending on how people spend their savings.

Given that vehicle fuel expenditures have a very low local economic multiplier, the economic effect of saving fuel is likely to be positive rather than negative regarding fuels. Thus, we have applied the 1.5 economic impact multiplier to fuel savings.

However, reduced auto repair expenditures are not likely to have a lower local multiplier than what the maintenance savings would be spent on, and may have a negligible or even negative local economic impact.

Endnotes

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[1] US EPA, Fuel Economy website: www.fueleconomy.gov/feg/maintain.shtml. For original data see: Oak Ridge National Lab, "Owner Related Fuel Economy Improvements," prepared by Energy and Environmental Analysis Inc., 2001, at: http://www.fueleconomy.gov/feg/pdfs/OwnerRelatedFuelEconomyImprovements.pdf.

[2] California Environmental Protection Agency, Air Resources Board, "Tire pressure check will save money, gas and lives," news release 26 March 2009, at: http://www.arb.ca.gov/newsrel/2009/nr032609b.htm.

[3] US EPA / Department of Energy, Fuel Economy website: www.fueleconomy.gov/feg/maintain.shtml.

[4] US EPA / Department of Energy, Fuel Economy website: http://www.fueleconomy.gov/feg/driveHabits.shtml. The Ecomodder website offers 108 driving techniques to improve fuel efficiency at: http://ecomodder.com/forum/EM-hypermiling-driving-tips-ecodriving.php.

[5] Joshua Zumbrun, "How to Increase your Gas Mileage," Washington Post, 6 August 2006, at: http://www.washingtonpost.com/wp-dyn/content/article/2006/08/03/AR2006080301403_2.html.

[6] Joshua Zumbrun, "How to Increase your Gas Mileage," Washington Post, 6 August 2006, at: http://www.washingtonpost.com/wp-dyn/content/article/2006/08/03/AR2006080301403_2.html.

[7] State of Arizona Department of Environmental Quality, Air Quality Vehicle Emissions report 2007-2009, at: http://www.azdeq.gov/environ/air/vei/download/032410stats.pdf.

[8] Provided by PAG's Senior Air Quality Planner Suzanne Cotty on behalf of PAG's planning staff, January 2011.

[9] The final regulation order by the CA Air Resources Board is available at: http://www.arb.ca.gov/regact/2009/tirepres09/tirefinalreg.pdf.

[10] City of Portland and Multnomah County, "Climate Action Plan 2009," p. 45, at: http://www.portlandonline.com/bps/index.cfm?c=49989&a=268612.

[11] City of Burlington VT, Climate Action Plan website, "Live A Greener Life," at: http://burlingtonclimateaction.com/what-you-can-do/live-a-greener-life/.

[12] City of Boulder, "Community Guide to Boulder's Climate Action Plan – 2009/2010 Progress Report," at: http://www.bouldercolorado.gov/files/Environmental%20Affairs/climate%20and%20ener

gy/Community_Guide/CAP_Guide-2010-final_with_council_justified.pdf. See also the GO Boulder website: http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=8774&Itemid=2973; and the Boulder Climate Action Plan of 2006 at: http://www.bouldercolorado.gov/files/Environmental%20Affairs/climate%20and%20energy/cap_final_25sept06.pdf.

[13] The diesel/gasoline consumption ratio was provided by Pima Association of Governments Air Quality program, and is used in the PAG's GHG Inventory 2010.

[14] US EPA, "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel," at: http://www.epa.gov/oms/climate/420f05001.htm.

[15] Prices are based on the following assumptions: Tucson gasoline prices are 5% below the national projection by the Electrification Coalition; diesel prices are 16% above the Tucson price. These assumptions closely reflect current prices of $2.75 per gallon for gasoline and $3.19 for diesel at the beginning of 2011.

[16] California Air Resources Board, " ARB clarifies requirement of tire inflation rule", Jan. 2010, at: http://www.arb.ca.gov/newsrel/newsrelease.php?id=81.

[17] Nitrogen Tire Inflation website, "Go Green With Nitrogen Tire Inflation," 11 May 2009, citing NHTSA studies, at: http://tirenitrogen.typepad.com/tirenitrogen/2009/05/index.html.

[18] A list of 65 potential modifications is available at: http://ecomodder.com/forum/fuel-economy-mpg-modifications.php.

Measure: Double Bike Lane Usage (T21)

Double bike lane usage in the City by 2015 by supporting the efforts of the City Bike/Pedestrian Coordinator, the regional Bicycle Advisory Committee, and continuing efforts to become a Platinum Bicycle Friendly Community as awarded by the League of American Bicyclists.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	16,084 tCO_2e (2020)
Percentage of goal (2012):	0.25%
Percentage of goal (2020):	0.71%
Total annual average implementation costs:	NA
Entity that bears the costs of implementation:	NA
Cost/Savings per tCO_2e:	Costs of added safety and infrastructure are not analyzed in this measure
Net annual savings:	$6.5 million in fuel savings
Entity that realizes the financial return:	Cyclists
Equitability (progressive/regressive, income/revenue neutral, etc):	Polices, promotional material, and infrastructure improvements can be allocated accordingly
Potential unintended consequences:	NA

Background information:

The Pima County Association of Governments (PAG) has a Regional Bicycle Master Plan, the origins of which date to 1975. Efforts continue striving to place Pima County as a nationally leading bicycle-friendly community. As evidence of this, the region was awarded Gold status by the League of American Bicyclists, becoming the first region to achieve this standard.[1]

Currently, there are four full time employees to promote bicycling within the community totaling at least 8,320 hours per year (including a full-time City Bike/Pedestrian Coordinator, Tom Thivener).[2] Beyond these full-time coordinators, PAG lists 22 other individuals whose full-time role is around bicycling in the region (not to mention other part-time and volunteer individuals who work to promote the many benefits of cycling).[3] Complimentary to the above, there is also a regional Bicycle Advisory Committee (BAC) that has formally been in place since 1987.[4] Finally, within the BAC, there are 5 subcommittees all of whom are devoted to expanding bicycling in the region.

It is for these reasons, we suggest that the Climate Change Advisory Community support these regional and local efforts.

Description of Measure and Implementation Scenario:

Double bike lane usage in the City by 2015 by supporting the efforts of the City Bike/Pedestrian Coordinator, the regional Bicycle Advisory Committee, and continuing efforts to become a Platinum Bicycle Friendly Community as awarded by the League of American Bicyclists.

It is not envisioned that the Climate Change Advisory Committee need to take a leadership role on this implementation given the ample resources bicycling enjoys in City and the region.

Business As Usual:

Business as usual in Tucson looks good provided the above positions remained filled and the community continues to work towards the Bicycle Friendly Community Platinum rating from the League of American Bicyclists.

Has the Measure been implemented elsewhere and with what results?:

Engaging community members to increase the percentage of bicycling relative to a city's multi-modal transportation system is not lost on many cities around the nation.

Tucson continues efforts to increase bicycle-ridership, and there do not appear to be significant gaps for the Climate Change Advisory Committee to fill in this effort.

Energy/Emission analysis:

In email communication with Tom Thivener, Tucson's City Bike/Pedestrian Coordinator, he stated the City does not have any bicycle miles traveled data specific to the City proper.[5] PAG projects the amount of regional weekday bicycle trips in 2005 to be 91,000.[6] Westmoreland Associates (WA) assumed that 75% of those trips were within the City's boundaries, that 50% were offsetting Single Occupancy Vehicle (SOV) light-duty trips, and that those trips occur 250 days per year. PAG puts the distance of bicycle trips at 6.6 miles per trip.[7] With these inputs, the amount of Vehicle Miles Traveled (VMT) currently reduced per year is 56.3 million miles.

The mandate is to analyze a doubling bike lane usage (taken to mean a doubling in the amount of non-recreational bicycle riding thereby offsetting VMT and the associated emissions). This analysis is based on meeting that goal by year-end 2015.

If this goal is met, the program will have saved the community over 127,000 tCO_2e by the end of 2020. The resulting GHG emission reductions in 2012 are over 4,700 tCO_2e and over 16,000 tCO_2e in 2020. CAFE standards and the projected reduction in MPG of light-duty vehicles as reported in the appendix of this report are figured into the VMT reduction analysis.

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline)[8]:	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	
2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Double Bike Lane Usage		
Contribution of T21 Double Bike Lane Usage (in 2020):	16,084	tCO_2e
2020 Contribution of T21 Double Bike Lane Usage:	0.71	%

Economic analysis:

Given the staff and funding allocations outlined above, we do not project any additional, GHG-specific, public funding being spent on this measure. The savings to the community based solely on a reduction in gasoline as a result of decreasing VMT over the coming decade amount to $65.1 million if the City is successful in doubling the amount of bike lane usage by year-end 2015 and maintaining that level through 2020. CAFE standards and the projected reduction in MPG of light-duty vehicles as reported in the appendix of this report are figured into the VMT reduction analysis.

We use the 1.5 multiplier to estimate the net positive impact on the City of Tucson economy from energy or water savings. This results in a net economic impact estimate of $97.6 million.

Co-benefits:

Many co-benefits exist relative to increasing bike usage. The Metropolitan Washington Coalition of Governments lists the following benefits[9]:

- Increased transit use
- Reduced transportation costs to households
- Public health improvement
- Increase traffic safety for cyclists because of critical mass
- Increased transportation access
- Congestion relief

Through the increased use of transit and reduced dependence on fuel, this measure should be in alignment with Tucson's other GHG adaptation measures.

Equitability:

Due to bicycle ridership being higher in areas of higher density and lower income, polices, promotional material, and infrastructure improvements can be allocated accordingly.[10]

Potential unintended consequences:

None identified.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] http://www.pagnet.org/documents/transportation/LABApplication2008.pdf

[2] Ibid

[3] Ibid

[4] Ibid

[5] Email communication dated January 14, 2011.

[6] http://www.pagnet.org/documents/transportation/LABApplication2008.pdf

[7] http://www.pagnet.org/documents/TRP/AnnualReports/AnnualReport2007-2008.pdf

[8] PAG Regional Greenhouse Gas Inventory- 2010

[9] Metropolitan Washington Council of Governments, "A Regional Bike-sharing System for the National Capital Region," application for US DOT TIGER grant funding, August 2010.

[10] http://www.pagnet.org/documents/bicycle/RegionalBicyclePlan2009.pdf

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Measure: Anti-Idling Ordinance (T20)

Design and implement a City-wide ordinance establishing time restrictions on voluntary idling and imposes a series of graduated penalties from warnings to fines for non-compliance. The measure should be accompanied by an extensive public outreach and education campaign, and a pilot program of idle-free zones throughout the City.

Nationwide, voluntary idling results in the estimated waste of 3.84 million gallons of gasoline each day (~1.4 billion gallons/year) and emits 33,433 metric tonnes of CO_2/day (12,203,804 tons/year).

COT ARRA RFP Summary:

Emission reduction potential by 2020:	15,188 tCO_2e
Percentage of goal (2012):	.2 %
Percentage of goal (2020):	.7 %
Total annual average implementation costs:	Nominal implementation cost to COT
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e:	$336 savings
Net annual savings:	$5.1 million
Entity that realizes the financial return:	Tucson driving population
Equitability (progressive/regressive, income/revenue neutral, etc):	Equity-neutral
Potential unintended consequences:	Possible initial public resistance

Background information:

Voluntary idling of vehicles is one of many daily actions that seem negligible but that, when taken cumulatively, can have a large impact on total emissions of carbon dioxide and on the environment more generally.

On a daily basis, Americans as a whole may be burning as much as 3.8 million gallons of gasoline from voluntary idling, which, in turn, results in producing about 35,000 metric tons of carbon dioxide.[1] Annually, the cumulative effect is significant, as U.S. drivers may be burning 1.4 billion gallons of gasoline and emitting over 12 million tons of carbon dioxide as a result.

An anti-idling ordinance is one of a suite of measures that a municipality can take to reduce idling. An anti-idling ordinance generally involves establishment of a time limit for individual vehicle idling after which penalties can be enforced. Other important variations in an ordinance include anti-idling fleet policies, the creation of idle-free zones with appropriate signage, education and community-based social marketing programs.

Business-as-Usual:

There are no anti-idling restrictions currently in place in Tucson. Absent this initiative, there will continue to be a significant amount of gasoline wasted on a daily and yearly basis.

Using the Hinkle Foundation analysis as a basis, Americans waste 3.8 million gallons of gasoline a day (or nearly 1.4 billion gallons/year). Arizona drivers (at 1.9% of the licensed drivers in the U.S.) would be responsible for 72,200 gallons of wasted fuel/day.[2] Based on a 2009 population estimate, Tucson's population of 548,555 is approximately 8% of the State's 6,683,129.[3] [4]

Uncontrolled and unnecessary idling by Tucson drivers may thus be responsible for 5,776 gallons of fuel wasted per day (3.8 million gallons/day x Arizona's 1.9% of licensed US drivers = 72,200 gallons/day by Arizona drivers x .08 Tucson percent of State population = 5,776 gallons/day). Annually, this amounts to over 2.1 million gallons of gasoline wasted due to idling by Tucson drivers.

Description of Measure and Implementation Scenario:

The recommended action is an ordinance that places time restrictions on voluntary idling and imposes a series of graduated penalties from warnings to fines for non-compliance.

There are several model idling control ordinances available online and one model by-law from Natural Resources Canada is referenced for use in framing a Tucson-specific ordinance.[5] The measures should be accompanied by an extensive public outreach and education campaign, enlisting experts in the automotive sector (mechanics, garages, auto dealers, etc.) to help deliver messages on the wear and tear, possible reduced engine life, and other vehicle damage of voluntary idling.

The City should also develop a pilot program of idle-free zones as part of the measure along with the public education and enforcement tools necessary to ensure that the benefits of reduced idling can be achieved.

We assume that a significant proportion of the city's licensed drivers, perhaps as many as 50%, drive very infrequently or are only part-time residents and do not drive for periods of the year. In our analysis, the bulk of the potential energy and emissions savings can be achieved by reaching the most active driving population in the city with outreach and education efforts.

Has the Measure been implemented elsewhere and with what results?

The impact of idling has long been recognized. Many countries have pursued anti-idling initiatives, including a nationwide campaign in Canada and regional campaigns in Japan and Great Britain. Domestically, at least 13 states have statewide anti-idling laws, and scores of counties and cities have their own anti-idling rules.[6]

In Arizona, there is an anti-idling ordinance in Maricopa County that limits idling to 5 minutes, with a set of fines along with exemptions to its 5-minute rule.[7]

No verifiable fuel savings data could be found from any anti-idling program. However, it is possible to estimate the extent to which drivers might change behavior as a result of an anti-idling ordinance and derive some conservative fuel savings, which we make an effort to do below.

Energy/Emission analysis:

From above, we estimate that Tucson drivers waste 5,776 gallons of fuel per day. The ordinance proposed in this initiative aims to reduce that number significantly, perhaps by as much as 80%.

While individual driver behavior change cannot easily be measured, we know that estimates of the amount of time an individual driver voluntarily idles each day he or she drives ranges from 5 to 10 minutes per car or more.[8]

We assume that the creation of an enforceable anti-idling ordinance results in the elimination of at least 5 minutes of idling per driver per day, perhaps more.

By designing an ordinance to discourage voluntary idling beyond 5 minutes, we project an annual gasoline savings of about 4,600 gallons per day (or 1.7 million gallons/year). This amount approximates the total volumes estimated above to be lost to idling within the city. This is justifiable to us in that we believe the bulk of the energy and emissions savings can be achieved by reaching the most active driving population in the city, here estimated at 50% of the licensed drivers, or 165,000 drivers.

This would begin with a phase-in of expected benefits as the new restriction becomes institutionalized beyond the first year. We project a quarter of the estimated 165,000 drivers (41,250) begin changing behavior the initial year with full implementation taking the balance of the decade to be realized.

A gallon of gasoline, when burned, creates 19.7 pounds of CO_2. Using the gallons-saved values in the preceding paragraph, the greenhouse gas emission reductions at full implementation of the anti-idling program would amount to 15,188 tCO2e.

In the first year, with 25% of the targeted savings achieved, emissions reductions would come to 3,797 tCO_2e. Savings per tCO_2e in 2020: $238

Climate Change Impact Summary:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure (2011-2020):	15,188 tCO2e

Economic analysis:

The cost of implementing an anti-idling ordinance would be subsumed in the routine traffic law enforcement responsibilities of the Tucson Police Department. However, coupled with an effective community-based marketing campaign an anti-idling ordinance may experience a fairy high degree of voluntary compliance, thus minimizing enforcement costs absent such a campaign.

Using Westmoreland's projections of gasoline and diesel prices in Tucson, the potential savings to Tucson drivers from lower vehicle fuel costs is estimated to total ~$65,554,000 from 2011 to 2020.

To estimate the total net financial impact of reducing voluntary idling, wear and tear costs from the increase in engine restarts needs to be considered. The maintenance costs from reducing voluntary idling are estimated to be no more than $9 per year per vehicle. Since each driver can only drive one vehicle at a time, we translate the $9 per vehicle to $9 per driver multiplied by 50% of the 330,000 drivers in Tucson for a cost to drivers of $1,485,000 per year.

Average net annual savings to Tucson's citizens is projected as $6,580,700 fuel savings less $1,485,000 maintenance costs = ~$5.10 million/year.

Using the economic impact multiplier of savings for Tucson citizens of 1.5, the net economic impact is projected to be ~$7.65 million.

Co-benefits:

There are several co-benefits to implementing idling reduction programs that target either municipal employees or drivers in the community:

1. Reducing idling from fleet vehicles reduces fuel consumption and extends engine life.[9]
2. Less idling also leads to reductions in smog precursor emissions and thus may reduce respiratory ailments.
3. Idling reduction programs are often very popular with residents who benefit from reduced noise and localized air quality deterioration.[10]

Equitability:

An anti-idling ordinance would be as equitable as any other motor vehicle moving violation law (speeding, illegal turns, etc.). Adherence to an anti-idling ordinance would be neither regressive nor progressive as it applies to drivers rather than to age, style, or cost of vehicle. Benefits in the form of reduced operating costs might actually be progressive in nature as vehicle operating costs generally represent a larger portion of a low-income individual's budget than they do for someone in a higher income bracket.

Potential unintended consequences:

Depending on the effectiveness of public outreach demonstrating economic advantages to reduced idling in conjunction with an anti-idling ordinance, such an ordinance could be viewed as an intrusion into the driving convenience and patterns of some everyday drivers.

Endnotes:

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[1] Anti-idling Primer: Every Minute Counts. Hinkle Charitable Foundation. http://www.thehcf.org/antiidlingprimer.html

[2] http://www.statemaster.com/red/pie/trn_lic_dri_tot_num-transportation-licensed-drivers-total-number

[3] http://www.azcommerce.com/econinfo/demographics/Population+Estimates.html

[4] http://www.city-data.com/city/Tucson-Arizona.html

[5] A Model Idling Control By-Law. Natural Resources Canada. http://oee.nrcan.gc.ca/communities-government/transportation/municipal-communities/reports/model-bylaw.cfm?attr=28

[6] For a summary of anti-idling regulations in the US, see: http://epa.gov/smartway/documents/420b06004.pdf

[7] Compendium of Idling Restrictions. American Transportation Research Institute. 2010.

[8] Anti-idling Primer. Op cit.

[9] Historically, rules of thumb for driving cars derived mostly from a time before electronic ignition became universal. New drivers were taught that turning off and on the car repeatedly would (a) wear out the battery, (b) wear out the starter, and (c) waste gas. Today, nearly every passenger vehicle engine (cars, SUVs, and pickups) uses electronic ignition and none of these three concerns exists any longer.

Battery technology has evolved today and early battery death is no longer common. In modern automobiles, batteries use less power per engine start, have greater power reserves, and recharge faster than they used to. Also, starters are stronger and more reliable today than they once were. When an engine idles it is not running at its optimum operating temperature and condition. This results in the incomplete combustion of gasoline that can leave fuel residues on the spark plugs, the cylinder walls, and other engine parts. These residues can corrode the engine parts, thereby shortening the life of the system, and can impair fuel efficiency when driving by as much as 4 to 5% according to Natural Resources Canada. For most cars in the fleet, idling neither protects the vehicle engines nor saves fuel. Rather, idling degrades the engine's ability to operate smoothly and efficiently while actually wasting gasoline.

Through field tests, the American Society of Mechanical Engineers Florida Section showed that restarting a car with a six-valve (V6) engine consumes approximately the same amount of fuel as idling for five seconds. Several other environmental groups advocate for either a "10-second" or a "30-second" rule. Natural Resources Canada (A Canadian Government Agency) stresses that idling is not an effective way to warm up a car. Even in winter, only 30 seconds is needed to warm the car's engine. Other vehicle parts, such as the axles, do not warm up until the vehicle is driven. For more information on this topic, see "Idling Reduction Programs for the Chicago Metropolitan Area. Illinois Sustainable Technology Center. October 2008.

Measure: Transit-oriented Development Initiative (T6)

This measure concerns a Transit-oriented Development Initiative (hereafter Initiative) that will maximize the City of Tucson's promotion and support of compact transit-oriented developments and supporting mass transportation development through 2020. The Initiative includes City-based incentives and regulations as well as policy advocacy activities with the county, regional and state governments that influence land use and transportation patterns.

The Initiative's key components are the following:

- Pursuit of full development of the region's High Capacity Transit corridors' transit systems by 2020 and corresponding redevelopment of corridor station sites into sustainably-designed transit-oriented developments.

- Continual improvement of Tucson's land use planning system to facilitate maximum use of compact and transit-oriented development techniques in infill projects, including financial incentives where necessary.

Emission reduction potential by 2020:	11,947 tCO_2e / yr.
Percentage of goal (2012):	NA
Percentage of goal (2020):	0.53%
Total annual average implementation costs:	NA – accelerating existing plans/trends for compact development that saves City infrastructure costs and increases tax receipts per developed acre
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e:	Savings $1,575 / tCO2e
Net annual savings:	$18.8 million
Entity that realizes the financial return:	Citizens living in compact developments enjoy reduced transportation and building utility costs
Equitability (progressive/regressive, income/revenue neutral, etc):	Likely progressive
Potential unintended consequences:	HCT Corridor transit systems and compact developments could increase traffic congestion

Background information:

Compact and transit-oriented development strategies center around increasing the density of the population in central areas of a city and minimizing outward auto-oriented growth (i.e. growing up instead of out).

This is accomplished through a combination of government policies affecting real estate economics such that the following are promoted:

(1) Infill development - converting existing structures into desirable living spaces and development of vacant lots in existing urban areas;

(2) Greater density of development, often through mixed-use development; and

(3) Creating appropriate transportation infrastructure to serve denser development (typically meaning increased mass transit services that reduce auto dependence).

In addition to reducing the energy and carbon intensity of the activities of organizations and individuals, compact and transit-oriented development reduces natural habitat destruction, improves real estate values, improves city finances by increasing tax collections per developed area, protect regional agricultural economies (which are typically damaged by sprawl development patterns), and can make a city more attractive to the young adult labor force that is critical to ongoing economic competitiveness.

The ten basic principles what's known nationally as Smart Growth apply to this Initiative:[1]

Mix land uses.
Take advantage of compact building design.
Create a range of housing opportunities and choices.
Create walkable neighborhoods.
Foster distinctive, attractive communities with a strong sense of place.
Preserve open space, farmland, natural beauty, and critical environmental areas.
Strengthen and direct development towards existing communities.
Provide a variety of transportation choices.
Make development decisions predictable, fair, and cost effective.
Encourage community and stakeholder collaboration in development decisions.

The plans of various regions leading the way on compact and transit-oriented development reflect strong relationships between development patterns and GHGs:

- Transportation
  - It is estimated that if US biking and walking levels returned to those of 1969, 1.5 million tons of carbon dioxide emissions would be saved annually.[2]

- Maximum deployment of compact (“Smart Growth”) strategies nationwide between 2010 and 2050 was projected to save US consumers over $1 trillion dollars of vehicle ownership and operational costs and reduce carbon emissions by 1.45 billion tons by 2050.[3]

- Compact development patterns reduce vehicle miles traveled (VMT) by an average of 35%. Each increment of compact development can be expected to reduce VMT 20-40%.[4] Regional growth plans emphasizing compact development are expected to reduce VMT an average of 8%, ranging as high as 32%. Analysis of a compact, mixed-use development in Atlanta compared to an urban edge site for same results projected a 35% VMT reduction.[5]

- Housing
  - A detached single-family home uses 54% more energy for heating and 26% more for cooling than a multi-family home.[6]

  - Homes in compact developments use, on average, 20% less energy than homes in sprawling development.[7]

- Infrastructure
  - The compact development plan scenario developed by Envision Utah for the Salt Lake City region was estimated to save $4.5 billion in infrastructure spending compared to continuing the existing sprawled development pattern.[8]

The State of Arizona’s Climate Action Plan (2006)[9] includes both a “Smart Growth Bundle” policy in the Transportation / Land Use section, and two policies in the Residential, Commercial and Industrial section, all adopted unanimously, summarized below:

- Smart Growth Bundle (TLU-2)
  - Measure: Target achievement of 2-11% reduction in VMT growth from passenger vehicles through a combination of development fees / fee waivers, smart growth bid package requirements, infill incentive district and other measures focused on:
    - Infill and Brownfield Development
    - Transit-oriented development
    - Smart growth planning
    - Targeted open space protection

  - Estimated cumulative GHG savings 2007-2020 (assuming 2006 adoption): 26.7 million tons CO_2e.

- Estimated cost per ton CO2e reduced: zero because it results in net savings.

- Building Standards/Codes for Smart Growth (RCI-4)
  - Measure: State should establish mandatory energy code or "strongly encourage" localities to maintain state-of-the-art codes and regularly update them.

  - Estimated cumulative GHG savings 2007-2020 (assuming 2006 adoption): 14.0 million tons CO2e.

  - Estimated cost per ton CO2e reduced: Net savings of $18 per ton CO2e.

- "Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)
  - Measure: Implementation of LEED or other green building certifications in state and locally funded buildings and promotion of practices to other buildings through financial incentives, use of life-cycle costing and education.

  - Estimated cumulative GHG savings 2007-2020 (assuming 2006 adoption): 18 million tons CO2e.

  - Estimated cost per ton CO2e reduced: Net savings of $17 per ton CO2e.

Status Quo / Business as Usual:

Arizona was ranked 15th of the 50 US states in a recent appraisal of carbon emissions-related state infrastructure policies (scoring 47 out of 100 points; the high was 93 and low was 0). However, Arizona received zero of the 25 points possible for Smart Growth policies and Transit-oriented Development Incentives.

Arizona also was ranked 15th concerning transportation investment decision-making processes, scoring all the possible ranking points regarding state support for non-motorized transportation and use of CMAQ federal funds, but was rated only 8 of 20 concerning the balance of state transportation investments and scored zero points regarding prioritization of highway maintenance and state contributions to public transit.[10]

The City of Tucson's existing real estate development process includes subarea plans that encourage compact and transit-oriented development. The Downtown Area Infill Incentive District Zone is designed to encourage sustainable infill partly through addressing barriers to infill development such as incompatible development standards, and to provide incentives.[11]

The City's Livable Tucson Vision Program of 1997 was a shared vision of the future and a common framework for action at the policy level. It includes an Infill and Reinvestment Goal for which key measures of progress include the ratio of city building permits to total regional permits, dollars reinvested in restoring and renovating inner-city buildings, ratio of protected natural desert to total developed land, and percentage of residences located within half a mile of a market.

Livable Tucson also adopted the following indicators of progress towards "Better Alternatives to Automobile Transportation": Use of alternative means of travel, miles of quality pedestrian and bike paths and bus routes to total lane miles of roads, and number of pedestrians in neighborhoods.[12]

In short, the Livable Tucson program is wholly supportive of this Initiative, but its lack of specific goals and regulations to achieve them means that the Climate Action plan could make an important difference towards performance. This analysis assumes that the Livable Tucson program will not, by itself, alter continuation of recent development patterns in Tucson.

The City adopted its Residential Green Building Rating System in 2009 in order to promote residential developers to build green developments.

A streetcar line four miles long, the Tucson Modern Streetcar, connecting downtown and the University of Arizona, will be opened in 2012. The line's expected 1.4 million annual ridership is projected to encourage transit-supportive development and redevelopment along the route.

Eight potential High Capacity Transit (HCT) corridors were identified in the 2040 Transportation Plan process as not having "fatal flaws." The two priority corridors are Broadway Blvd. and 6th Ave / Nogales Hwy. Transit-oriented development principles are already part of the planning for the corridors, including transit-encouraging densities and intensities, parking management to promote alternative mode use, and mixed uses.

Funding for the high capacity transit systems is the primary obstacle to HCT plan implementation that the City of Tucson must address for the HCT component of this measure to succeed.[13]

According to the City's Planning and Development Services Department, transit-oriented developments or compact developments are often prohibited or hindered by existing plans and zoning regulations, but the City's staff is working to free up processes through projects such as the Downtown Infill Incentive District and developers are beginning to show interest in compact developments as financing again becomes available.

Description of Measure and Implementation Scenario:

Building on traditional land-use planning practices of restricting development uses, densities and designs through zoning and/or incentives, the Initiative follows the practices of leading-edge urban areas in the US to set specific land-use redevelopment targets linked to transportation system development strategies.

More specifically, the initiative involves:

- Maximizing infill development and redevelopment in the City through 2020 such that:
    - 2000 units are under contract for redevelopment at compact development densities.

- Accelerating development of the High Capacity Transit corridors such that:

    - All six recognized non-freeway corridors have seen the transit system installed at the BRT Exclusive Lane (BRT XL) or street car level (Campbell Ave. north only) by 2020; and

    - Transit-oriented compact developments 3 acres in size built at an average of 20 residential units per acre are completed or under contract for development at 50% of identified stations or otherwise every one mile.

Maximizing Infill:

The Initiative is a flexible set of activities primarily conducted by the City of Tucson that will stimulate 100 acres of compact development or redevelopment in the City that would not have otherwise occurred by 2020. Expected actions are zoning/code changes and potentially financial incentives.

High Capacity Transit Corridor Development:

Of the eight high capacity transit corridors identified in the PAG High Capacity Transit System Plan, six are on roadways subject to compact developments at stations (transit-oriented developments). The other two are freeway routes that are not scheduled for transit service that would stimulate compact developments.

The Initiative's goal is funding and implementation of BRT exclusive lane transit systems by 2020, supported by City land-use planning processes, such that 50% of likely station sites are under redevelopment as compact developments averaging 3 acres at a density of 20 residences per acre.

Funding of the transit systems should include identified sources of revenues to cover the capital costs and at least five years of the operational subsidies required.

Note that the HCT study concluded that only 2 Broadway Bl. sites and zero sites on the 6th Ave. / Nogales line are presently suitable for "major transit-oriented development." Along the 6th Ave. / Nogales line, the study found that "smaller parcels could be combined to create mixed-use residential/commercial redevelopment opportunities that would benefit from a BRT or streetcar line." One major ToD redevelopment opportunity was identified for Campbell Ave North – the UA Agricultural Farm.[14]

The table below shows the roadway corridors, their length, transit-oriented station developments and expected annual ridership.

Table 1: Transit-oriented compact development sites on HCT corridors

Corridor	Service	Length (miles)	Stations*	Annual Ridership Projected (000s)
Speedway	BRT XL**	10	10	1,121
Broadway	BRT XL	12.5	16	1,205
Oracle	BRT XL	16	16	1,099
Grant	BRT XL	7.5	8	435
Campbell S/Kino	BRT XL	8.5	8	435
6th Ave / Nogales Hwy	BRT XL	9	15	1,053
Campbell N	Street Car	5.3	5	224
Total Stations with Redevelopment Potential:			***78***	

*See Attachment A for a station list where applicable. Some corridor stations are assigned to another corridor to avoid double counting. Where station lists have not been provided by the HCT Plan, this analysis assumes one station with redevelopment potential every one mile.

** BRT XL means Bus Rapid-transit with an exclusive lane.

Has the Measure been implemented elsewhere and with what results:

Numerous metropolitan areas have adopted Smart Growth policies in the past ten years; only a few have specifically identified expected carbon emissions savings from implementation. Similar cities throughout the US have been implementing high-capacity transit corridors accompanied by transit-oriented developments.

Sacramento, CA

The Sacramento Council of Governments adopted a regional growth "preferred blueprint" based on Smart Growth principles in 2004 as part of its 2035 regional transportation plan. It won the Association of Metropolitan Planning Associations' National Achievement Award for 2004. Key goals are reduction of vehicle miles traveled and reduction of traffic congestion. A number of transportation-based tactics are involved such as more inner-city HOV lanes, greater roadway maintenance, pursuit of state/federal regulatory reform for better support of Smart Growth, and non-auto infrastructure investments.

The plan predicted that by following the preferred Smart Growth-based blueprint, carbon emissions per capita would be reduced 14% by 2050 from the base case (continuation of the existing land-intensive suburban growth development pattern).

This result is partly from reducing the number of trips taken by car about 10% and tripling the number of trips using transit from one to three percent. Total transit and walk/bike trips using Smart Growth were projected to be 16% instead of the existing 8% rate and 6% in the base planning case. Daily vehicle minutes of travel per household is projected to be reduced nearly 20% from the base case of 81 minutes.

Most dramatically, the preferred blueprint would bring 41% of jobs and 38% of housing within walking distance of 15-minute or better transit service, compared to only 5% of jobs and 2% of housing in the base case scenario. This reflects a key blueprint component: The addition of housing near the region's three primary employment centers. Such housing proximities reduce vehicle miles travelled ~30%; the plan is expected to reduce vehicle miles traveled per household per day from 42 to 35, which is over 25% below the base case scenario.

The plan aimed to change the dominant housing pattern from 80% large lot single-family homes to 70% small single-family detached or multi-family development typically fours stories high. This process was described as well under way at a conference reviewing the plan's first five years in early 2010. Transit priority areas were established for 15-minute transit service by 2035, which determined the preferred housing development (including mixed-used development) areas for 175,000 new housing units.

Implementation is primarily by regional county and local governments, largely through Smart Growth policies such as form-based codes and incentives for infill and transit-oriented developments. The City of Lincoln's implementation includes a neighborhood electric vehicle transportation plan. The City of Sacramento adopting a community Climate Action Plan by July, 2011. Regional cities that are signatories to the US Mayors Conference Climate Agreement include Citrus Heights, Elk Grove, Galt, Sacramento, West Sacramento and Winters.

Stakeholders at a five-year review of the blueprint in April 2010 strongly supported the plan's objectives, and identified raising the funds for the required improvement of transit systems followed by developers finding a profitable balance between new housing costs and affordability as the top two implementation challenges. Revitalization of downtowns and neighborhoods in transit corridors was strongly chosen (4.7 of a possible 7 points) as the main benefit of the new housing location and design policies, followed by reduced traffic congestion through increased transit usage (2.7), and reduced conversion of agricultural land (2.3). Over two-thirds of stakeholders responded that implementation of the blueprint was "very important" to the future quality of life in the region.[15]

Portland, OR

The City of Portland was an early adopter of Smart Growth policies. A climate plan was adopted in 1993 and has been continually updated; a three-year plan was adopted in 2009 comprising 100+ actions to achieve the goals of a 40% reduction by 2030 and an 80% reduction by 2050 from 2008 GHG emissions levels.[16] The City's planning department has been merged with sustainability promotion as the Bureau of Planning and Sustainability under a unified citizen's commission.

Partly due to Smart Growth-based planning, community-wide (county) GHGs have decreased 15% since 2000 and 2% below 1990; per capita emissions have decreased 20% since 1990.[17] Smart Growth efforts to date resulted in 44% of new dwellings designed into mixed-use developments by 2009. The City's Smart Growth efforts are partly a result of the regional urban growth boundary that encourages dense rather than sprawled development, as well as the City's landlocked boundaries and desire for continual economic development.

The City is in the process of adopting its 25-year (to 2035) strategic Portland Plan. Smart Growth related objectives include:

- Creating "complete twenty-minute neighborhoods" that facilitate 90% of citizens to "easily walk or bike to meet all basic, daily non-work needs."
- Increase the numbers of commuters who walk, bike, take transit or telecommute from 28% to 70%.
- Increase new dwellings built in mixed-use areas to 75%.
- Design and manage streets to accommodate non-auto modes of travel giving first priority to investments that support walking, biking and universal accessibility.
- Reducing household energy use 20%.

- Reducing impervious areas 15%.
- Creating “green corridors” along major streets.
- Increasing “access to nature” such that all citizens are within one-half mile of nature.

Stamford, CT

Stamford adopted a Sustainability Amendment[18] to its existing master plan in December, 2010 partially to address greenhouse gas emission reductions. The City had joined ICLEI’s “Cities for Climate Protection Program” in 2003, and developed its “Local Action Plan: Greenhouse Gas Emission Reductions” in 2005 that provided a strategy for the City to reduce GHG emissions 20% by 2018 from a 1998 baseline. The Sustainability Amendment suggests sustainability metrics such as solid waste recycling rates.

The Sustainability Amendment addresses Land Use and Transportation, Energy and Climate, Open Space and Natural Resource Management, Infrastructure and City Services, New Construction and Existing Buildings, Adaptation and Mitigation, and Community Involvement and Education. Relevant strategies and objectives to Smart Growth include the following:

- Direct growth toward areas with strong transit access through nine strategies including:
  - Master plan and zoning regulations that support transit oriented developments;
  - Requirements that developers use (1) the LEED Neighborhood Development Project Scorecard for site plan review and (2) submit Parking and Transportation Demand Management plans;
  - City design of streets to support/enhance access between neighborhoods and neighborhood-level commercial developments and adopt “Complete Streets” design standards.

- Transportation plans will promote reductions in vehicle trips and encourage alternative modes through twelve strategies including:
  - Promoting remote working options;
  - Master planning expansion of the existing Transportation Center;
  - Enhancing and promoting transportation alternatives;
  - Reducing required parking; and
  - Promoting car sharing.

- Reduce the City’s carbon footprint by:
  - Requiring all new developments to meet minimum green performance levels and report projected GHG emissions;
  - Encourage retro-commissioning of all major facilities;
  - Require sub-metering of multi-tenant buildings;

- Provide incentives for use of green / “Cool” roofs
- Create incentives for sustainable development such as excluding from property taxes incremental value resulting from adopting sustainable practices and expediting permitting processes for sustainable projects.

Other Estimates of the Compact Development / Carbon Emissions Relationship

Below are the relationships found by Monterey Bay CA and new RapidFire Modeling Tool developed by Calthorpe Associates regarding the effects of compact and transit-oriented development plans on carbon emissions:

- Monterey Bay CA: The Association of Monterey Bay Governments issued in November 2010 a “Blueprint for Sustainable Growth and Smart Infrastructure.” If the “sustainable growth patterns” are followed, per capita greenhouse gas emissions are projected to be only 1.1% more than 2005 levels in 2035 instead of 13.7% via “current growth patterns.” The region’s target for annual per capita carbon emissions in 2020 is 14.1 pounds, decreasing to 13.4 by 2035. The sustainable growth pattern estimate used the EMFAC 2007 model, but the Association notes that it, along with many other California planning agencies, are “continually updating modeling capacities in order to better estimate how Smart Growth policies can reduce GHGs.”[19]

- The Rapid Fire Modeling Framework uses the following assumptions leading to an estimated reduction of 17% of GHG emissions from transportation and buildings in its Growing Smart scenario and 48% from its Green Future scenario compared to its Business As Usual scenario:[20]

    - Gasoline prices will increase 2.4% per year to 2020 in real dollars, reaching $4 per gallon in 2008 dollars.

    - Urban development characterized by high levels of regional and local transit service will help people use only 1500-4000 VMTs per capita per year, whereas “Compact” development results in VMTs per capita of 4000-7500 per year, and “Business As Usual” development results in 9500-18,000 VMTs per capita annually. The “Growing Smart” or “Green Future” development scenarios can be expected to reduce 2005 VMTs by 18% by 2035 whereas Business As Usual would increase 2005 levels (8100 miles per capita) by 8%.
        - Reduced VMTs are projected to lead to a reduction in driving costs per household from $14,600/yr in Business As Usual to $11,100 in Growing Smart and $9,900 in the Green Future scenario.

        - Annual GHGs per capita by 2035 are projected to decline 35% from 2005 levels in Business As Usual, 49% in the Growing Smart scenario and 72% (from 8500 to 2390) in the Green Future scenario.

    - Residential building GHG emissions are projected to be about 10% less via Growing Smart and 30% less via Green Future scenarios than Business As Usual.

- Green development policies can be expected to reduce energy use of new buildings to 55% below 2005 levels by 2035, whereas "Trend" development policies will only reduce energy use 20%.

Energy/Emission analysis:

This analysis assumes the following:

- Infill: 100 acres of City infill developments outside HCT planning areas are done as "compact developments" (20 residential units per acre) *that would otherwise have been* "business as usual"[21] developments by 2020 (refinement of this rough estimate is recommended if this Initiative is developed.)

- HCT Corridors:
  - 50% of the 78 identified or estimated stations are redeveloped by 2020 at the average size of 3 acres at 20 dwelling units per acre.

The total acreage that becomes compact development by 2020 due to the Initiative is the following:

Infill: 100 acres
HCT areas: 117 acres
Total: 217 acres

Analyst Reid Ewing estimates the VMT-related carbon emissions reductions from compact development using the following ratios:[22]

- % VMT reduction from regular development patterns: 30%
- Ratio of carbon emissions reduction to VMT reduction: 90%

Using these carbon reduction ratios and the acreage figures above, this report estimates that this Initiative has the potential to reduce Tucson CO2 emissions in 2020 (counting projects under way but not yet completed by 2020) by the following amounts:

- Transportation
  - 217 acres at 20 units per acre = 4340 units
  - Baseline is 2005 annual transportation-related pounds of CO2e per capita of 8,500 lbs., and two people per 4340 units = 73.8 million lbs.
  - Compact development reduces emissions by 27% (90% of 30% VMT reduction) = 19,920,600 lbs = 9,034.
- Buildings
  - Annual Residential Emissions per Household: 3.36 tCO2e
  - 30% reduction from compact development's multi-unit buildings: 0.67 tCO2e per unit.
  - Total emissions reduction from the Initiative: 4,340 tCO2e

The estimated total reduction from Business As Usual development patterns of 4,340 units to compact development units because of the Initiative is: 13,374 tCO2e per year.

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	11,947 tCO_2e

Economic analysis:

The HCT Plan estimated the capital costs as follows (including park and ride lots):[23]

Broadway Bl. BRT: $29 million
6th Ave. / Nogales Hwy BRT: $17.5 million
Campbell Ave. North Streetcar: $198.5 million

Based on the average per mile BRT capital costs for Broadway and 6th Ave. / Nogales of $1.2 million, the following estimates have been made regarding development of the Speedway, Oracle, Grant and Campbell S/Kino corridors:

Speedway: $12 million
Oracle: $19.2 million
Grant: $9 million
Campbell S/Kino Parkway: $10.2 million

The total estimated capital costs for the HCT Plan are:

$96.9 million for the 62.3 miles of BRT exclusive lane routes
$198.5 million for the 5.3 miles of streetcar
$295.4 million combined

The net costs of these investments to the citizens of Tucson have not been estimated. Net cost calculations would require meaningful estimates of:

- The costs of maintenance of the roadways that would be replaced by the BRT lanes and maintenance savings throughout the City from the reduction of vehicle miles traveled by transit-oriented development residents;

- The capital costs covered by non-City sources, such as Federal transit development grants;

- The annual subsidies required by the transit routes, if any; and

- The increased City tax revenues from the compact redevelopments.

This analysis uses an estimate that 50% of the HCT transit capital costs (estimated at $295.4 million) are provided by non-Tucson sources (most likely Federal grants), and that transit system operating subsidies required are balanced by reduced roadway maintenance costs and increased property taxes from redevelopments such that transit operating costs are not a net cost to Tucson citizens.

Initial estimated Tucson Costs – HCT Transit component of Initiative: ~$147.7 million.

The HCT study lists eight feasible sources for the City's funding requirements for capital and operating costs. The equitability of this Initiative would depend on the choice of funding sources.[24]

These investment costs will be offset by savings accruing to the City and citizens from HCT development. It is too preliminary to estimate the savings, but sources of savings would be the following:

- Vehicle operation savings (a citizen who was able to meet mobility needs without a private vehicle could save $400+ per month).

- City infrastructure development and maintenance savings: It is estimated that compact or transit-oriented developments are 48.6% less costly to a citizenry because of reduced infrastructure requirements per square foot of residential or commercial development.[25]

Experience in other transit corridor developments has shown that completing transit investments earlier rather than later can reduce development costs. As the Pima Association of Governments has included the HCT corridors in its transportation plan, it is reasonable to assume that the investments will be made regardless of this Smart Growth Initiative, and that advancing the construction dates of the systems would result in cost savings to Tucson residents. However, the savings are impossible to predict.

Therefore, this analysis assumes no special costs regarding transit corridor development are generated by the Initiative, and the only economic impact are the projected savings on building energy and transportation costs accruing to the ~8,700 residents of the 4,340 units built to compact standards because of the Initiative.

The annual savings that residents of the units would begin to enjoy are calculated as follows:

- Transportation:
    - VMTs per capita are expected to be reduced 30% from 8500/yr. baseline of 2005.
    - Costs of each VMT that costs $.50 today projected to rise 60% by 2020 based on projected 60% fuel increase (Westmoreland Associates Tucson projection) = $.80/VMT.
    - Vehicle savings per person in compact development = $2,040
    - Two people in each of 4340 units = 8680 people X $2,040 savings = $17.7 million.

- Buildings:
    - Multi-tenant buildings typically reduce energy costs 20%.
    - Average single-family home energy costs in Tucson in 2010: $100/month
    - Expected utility cost increases to 2020 of 7%: $107/month
    - 4340 units expected to save 20%: $1.1 million

Total annual savings projected for 8680 residents of 4340 compact development units starting in 2020: $17.7 million + $1.1 million = $18.8 million savings accruing to the people living in the compact developments.

At the savings multiplier used in this analysis, the annual positive economic impact is projected at $28.2 million.

Co-benefits:

The Initiative's co-benefits include the following:

- Reduced health care costs, particularly for obesity and its related maladies. For example, if compact development land use policies were to eliminate the six extra pounds per person estimated to result from sprawled development patterns, the citizens of Oregon might annually save $206,000,000 in health costs. The following estimates of maximum annual health savings from greater walking due to compact development policies were made for the Portland OR region:[26]
    - Street connectivity: $23.2 million
    - Population density: $8.4 million
    - Retail employment density: $0.5 million
    - Employment density: $0.2 million

- Other environmental benefits
    - Reduction of outdoor water use. For example, higher residential density in Salt Lake City UT reduced residential water use 50%.[27]

Additional co-benefits of the proposed Initiative are likely to include:

- Reduced traffic congestion and related health impacts.

- Increased property taxes per developed acre, and a more positive ratio of City infrastructure revenues to costs.

Equitability:

The compact or transit-oriented development concept is often used to ensure adequate development of affordable housing, though this strategy is not required. For example, the new Yale Station transit-oriented development project in Denver adjacent to a light-rail station combines retail and covered parking with 50 affordable senior housing units.[28]

Equitability will largely depend on the sources of funds used to pay for the City of Tucson and other government's investment in this Initiative. The Initiative has potential to be very positive from an equitability perspective if the transit systems allow lower income people to avoid the costs of private vehicle ownership, presently $500+ per month.

Potential unintended consequences:

Compact developments or exclusive-lane transit aren't everyone's preference. By adopting this measure to promote 50% of new City of Tucson infill development to fit Compact or transit-oriented development patterns, it is possible the City would reduce its overall redevelopment potential if developers perceive that far less than 50% of development customers (residential and commercial) wish to participate in compact developments.

In addition, the use of exclusive lanes for transit on existing roadways that cannot be widened have the potential to increase traffic congestion.

Attachment A: HCT Station Sites

This analysis assumes that 75% of the stations listed below in the PAG's HCT plan are redeveloped as compact developments. Where the PAG plan did not list likely stations, the analysis assumes one potential station every 0.5 miles, of which 75% are redeveloped.

Broadway Boulevard corridor, System Alternative A

- Ronstadt Transit Center
- Broadway Bl. and Euclid Ave.
- 6th St. and Park Ave.
- 6th St. and Cherry Ave.
- Broadway Bl. and Campbell Ave.
- Broadway Bl. and Tucson Bl.
- Broadway Bl. and Country Club Rd.
- Broadway Bl. and El Con Mall
- Broadway Bl. and Swan Rd.
- Broadway Bl. and Craycroft Rd.
- Broadway Bl. and Wilmot Rd.
- Broadway Bl. and Kolb Rd.
- Broadway Bl. and Pantano Rd.
- Broadway Bl. and Camino Seco
- Broadway Bl. and Harrison Rd.
- Broadway Bl. and Houghton Rd.

6th Ave. / Nogales Hwy corridor, System Alternative A

- Ronstadt Transit Center (counted as Broadway corridor)
- Stone Ave. and 14th St.
- 6th Ave. and 14th St.
- 6th Ave. and 18th St.
- 6th Ave. and 22nd St.
- 6th Ave. and 26th St.
- 6th Ave. and 29th St.
- 6th Ave. and 34th St.
- 6th Ave. and I-10
- 6th Ave. and Veterans Bl.
- 6th Ave. and Ajo Way
- 6th Ave. and Illinois St.
- Laos Transit Center
- Nogales Hwy and Valencia Rd.
- Valencia Rd. and Campbell Ave.
- TIA

Campbell Avenue North (streetcar line)

- Campbell Ave. and Helen St.
- Campbell Ave. and Elm St.
- Campbell Ave. and Grant Rd.
- Campbell Ave. and Copper St.
- Campbell Ave. and Glenn St.
- Campbell Ave. and Blacklidge Dr.

Campbell Ave. and Ft. Lowell Rd.
Campbell Ave. and Kleindale Rd.
Campbell Ave. and Prince Rd.
Campbell Ave. and Allen Rd.
Campbell Ave. and Limberlost Dr.
Limberlost Dr. and Mountain Ave.
Limberlost Dr. west of Fremont Ave.
Limberlost Dr. and 1st Ave.
Limberlost Dr. and west of 4th Ave.
Stone Ave. and south of Mills Dr.
West of Tohono Transit Center

Endnotes

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Measure: Purchasing Incentives for Zero Emission Vehicles and Plug-in Hybrid Vehicles (T7)

A fee-bate structure is created for the period 2011-2020 that collects fees from general- or transportation-related activities (e.g. vehicle registrations, sales taxes) that are used to provide sufficient funds (~$22.65 million) for rebates (average of $3,850/vehicle) to Tucson citizens and organizations to purchase Zero Emission Vehicles (ZEVs, a.k.a. all-electric vehicles or EVs) and PHEVs (plug-in hybrid electric vehicles).

The measure's goal is to triple Tucson purchases of ZEVs and PHEVs from 2011-2020 compared to the "business as usual" scenario in which Tucson purchases are just Pima County's share of the national market for new vehicle sales (0.21%). The measure is expected to result in 5,835 ZEV/PHEV vehicle purchases beyond business-as-usual during the 2011-2020 timeframe.

Emission reduction potential in 2020:	10,780 tCO_2e
Percentage of goal (2012):	0.006%
Percentage of goal (2020):	0.48%
Total annual average implementation costs:	$0 due to revenue neutral fee-bate system covering rebates and administration
Entity that bears the costs of implementation:	Revenue neutral fees are proposed to pay for program, meaning costs are borne by fee payers – likely to be citizens of Tucson but potentially including visitors if sales tax used
Cost/Savings per tCO_2e:	Savings of $10 / tCO2e
Net annual savings:	$ 0.65 million
Entity that realizes the financial return:	Zero-emission / PHEV Vehicle owners
Equitability (progressive/regressive, income/revenue neutral, etc):	Depends on source of implementation costs. Example: Regressive if fees from all auto registrants are used. Progressive if fees on inefficient new car sales are used.
Potential unintended consequences:	Slight potential for reduced economic activity as a consequence of the fees that fund the fee-bates

Background information:

This measure is predicated on two factors, one human and one physical. First, consumers will often respond to sale prices, or “deals” even to the point of altering purchase locations due to small differences in local sales taxes, especially on major purchases like appliances or vehicles.

Second, a direct relationship exists between a vehicle’s energy consumption and its carbon emissions, meaning that dramatic GHG reductions per capita can occur through leaps in the fuel-efficiency of vehicles. ZEVs are projected to average 100 miles per gallon equivalent (MPGe) and PHEVs to average 80 MPGe, whereas the average MPG in Tucson today is ~20 for gasoline vehicles.[1]

Arizona is one of 13 states that adopted the California standards defining Low-Emission Vehicles (LEVs) and Zero-Emission Vehicles (ZEVs). ZEVs operate with electricity as the vehicle’s sole fuel, though the specific propulsion system in the vehicle may be batteries, hydrogen fuel-cells or compressed air piston engines.

Plug-in electric hybrids (PHEVs) are designed to operate solely on their electric batteries until they are discharged, after which the vehicles will use a petroleum-based (gasoline or diesel) engine to generate electricity. Like ZEVs, they are propelled solely by electric motors, whereas today’s gasoline hybrids are propelled by either a petroleum engine or electric motors, depending on the situation.

ZEVs and PHEVs are also called Grid-enabled Vehicles (GEVs) because their sole or primary fuel comes from the nation’s electric grid.

ZEVs may achieve about three to six times the vehicle fuel efficiency of regular gasoline fueled vehicles. The Nissan Leaf has received an EPA miles-per-gallon equivalent (MPGe) rating of 99;[2] lighter-weight prototypes such as the Motive Kestrel or Aptera may achieve 200+ MPGe.[3]

ZEV efficiency greatly varies according to weight, aerodynamic drag, and specific conditions such as weight of loads, topography, electric loads (especially air conditioning) and driving style. The wide variance of electric vehicle fuel efficiency for a single battery charge is shown by Nissan’s stated range for the Leaf’s 24 kilowatt-hour battery pack: 62 to 138 miles.[4]

The cost of lithium-ion batteries is the primary barrier to ZEVs and PHEVs being cost-effective for buyers. It is estimated that current models’ battery packs are costing manufacturers $600-850 per kilowatt-hour (kWh), whereas Nissan needs to achieve $370/kWh for its Leaf model to be profitable, which many experts predict will take a decade. The US Department of Energy projects that PHEVs will need battery costs from $168-280/kWh to be cost-competitive.[5]

In this analysis, Westmoreland Associates estimates ZEVs to achieve 100 MPGe and PHEVs 80 MPGe. The resulting CO_2 emission savings per vehicle per year compared to a 30 MPG gasoline vehicle, assuming 10,000 miles driven per year and ZEVs/PHEVs substitute for gasoline vehicles, would be:

ZEV:	4,597 pounds $CO_{2;}$	70% reduction,
PHEV:	4,104 "	"; 63% reduction.

This does not take into account the carbon intensity of coal and the use of coal for ~50% of US electricity generation. An Argonne National Labs lifecycle estimate of the "well to wheel" carbon emissions of a ZEV found only an estimated one-third reduction in carbon emissions from a gasoline vehicle, largely because of that consideraion.[6]

Another study by the Electric Power Research Institute collaborating with the National Resources Defense Council estimated a range of 29% lifecycle emissions reduction from gasoline for ZEVs using coal-fired electricity to 67% reduction if using renewable-sourced electricity.[7]

These vehicles (e.g. the PHEV Chevy Volt or Toyota Prius models, to be launched in 2011, or retrofitted gasoline hybrids) will require numerous advanced technologies and a lithium-ion battery-pack costing ~$10,000 in the near-term, giving a significant upfront cost disadvantage. The retail price of the ZEV Nissan Leaf is $32,500; the PHEV Chevy Volt $41,000. In addition, owners may wish to invest ~$2,000 in rapid charging infrastructure at vehicle storage sites at their homes or fleet service sites.

This report recommends that Tucson, Pima County and the State of Arizona collaborate to follow the lead of various states that consider ZEVs or PHEVs worthy of major financial incentives of at least $5,000 when coupled with the Federal government's incentive of $7,500.

To illustrate the ZEV initial cost challenges, expected through at least 2012 if not the entire decade, the table below shows the number of miles that a ZEV vehicle (modeled on the Nissan Leaf) must be driven to save the owner as much in fuel costs as the owner has paid in higher purchase costs. The ZEV is compared to a gasoline vehicle achieving 30 MPG and costing either $15,000 or $20,000.

The scenarios address current Federal purchase rebates of $7,500 and additional rebates of $5,000 offered by some states (total of $12,500). The analysis uses the retail cost of a Nissan Leaf ZEV of $32,500 and fuel efficiency estimated at 100 MPGe using electricity costing the national average of ~$.10/kWh. Maintenance costs are assumed to be identical, though some experts predict maintenance costs for ZEVs to be lower than for regular vehicles.

Gasoline costs are the US average of $2.82 for 2010, and a hypothetical $4.00 in the future. Note that Westmoreland Associates has projected Tucson gasoline costs to be $3.01/gallon in 2011 rising to $4.09 by 2016 and $4.37 by 2020.

Table 1: ZEV Miles of Fuel Savings to Breakeven from Higher Purchase Costs

Scenario	Miles to Breakeven*	
ZEV cost: $32,500		
Comparable gasoline car cost:	**$15,000**	**$20,000**
Gasoline price $2.82/gallon, no rebates	254,000	181,000
Gasoline price $4/gallon, no rebates	162,000	115,000
Gasoline price $2.82/gallon, $7,500 rebate	145,000	72,000
Gasoline price $4/gallon, $7,500 rebate	92,000	46,000
Gasoline price $2.82/gallon, $12,500 rebates	72,000	0
Gasoline price $4/gallon, $12,500 rebates	46,000	0

* - Number of miles required at fuel savings based on 10 cents per kilowatt hour electricity costs to achieve a breakeven point where the initial higher cost of the vehicle is saved through fuel savings.

Table 2 below shows the same comparisons as Table 1 but for a PHEV assumed to achieve 80 MPGe combined while driven 40% on electric batteries (meaning achievement of 66 MPG during the 60% of miles using gasoline), and an initial purchase cost of $35,000.[8] Note that the Chevy Volt was rated at only 37 MPG on gasoline by the EPA; Westmoreland's assumption of 66 MPG is based on tests of lighter-weight PHEV designs that will achieve higher gasoline MPG.

Table 2: PHEV Miles of Fuel Savings to Breakeven from Higher Purchase Costs

Scenario	Miles to Breakeven*	
PHEV cost: $35,000		
Comparable gasoline car cost:	**$15,000**	**$20,000**
Gasoline price $2.82/gallon, no rebates	343,000	257,000
Gasoline price $4/gallon, no rebates	230,000	172,000
Gasoline price $2.82/gallon, $7,500 rebate	214,000	128,000
Gasoline price $4/gallon, $7,500 rebate	144,000	86,000
Gasoline price $2.82/gallon, $12,500 rebates	129,000	43,000
Gasoline price $4/gallon, $12,500 rebates	86,000	29,000

* - Number of miles required at fuel savings based on 10 cents per kilowatt hour electricity costs to achieve a breakeven point where the initial higher cost of the vehicle is saved through fuel savings.

Assuming that most consumers will want their initial higher cost investment for a ZEV or PHEV to be paid back within 75,000 miles, the only scenarios that will are likely to result in ZEV/PHEV sales to average vehicle buyers are those with Federal and State rebates totaling ~$12,500 unless consumers compare the ZEV or PHEV to a $20,000 gasoline car instead of a $15,000 car and if/when gasoline prices rise above $4 per gallon. The US Department of Energy does not consider that likely before 2015.

Regarding future gasoline prices:

- The official predictor of future US energy prices is the US Energy Information Administration's annual Energy Outlook. The 2010 Outlook predicts the most likely scenario (a.k.a. its "Reference case") of average US gasoline prices in 2015 to be $3.07/gallon. If global factors keep oil prices low, the US gasoline price is predicted to be $2.06/gallon; the "high oil price" scenario predicts $4.19/gallon. The wide range illustrates the great uncertainty in energy markets.[9] The EIA's short-term outlook for 2011 published January 2011 predicts a national average of $3.17/gallon for 2011 and $3.29 for 2012.[10]

- The average US gasoline price predicted by the modeling of The Electrification Coalition is $3.35/gallon for 2012; $4.17/gallon for 2015; and $4.56/gallon for 2020.[11]

- Westmoreland Associates has projected Tucson gasoline prices 2011-2020, pegging Tucson prices as 5% below the US EIA projection for 2011 of $3.17/gallon and thereafter 5% below the Electrification Coalition projections.[12]

In short, the most likely scenario for adoption of high efficiency PHEV and ZEV vehicles is very slow marketplace penetration unless petroleum prices rise faster than presently expected.

The role of government rebates is therefore more crucial in reducing carbon emissions from PHEV/ZEV vehicles until a combination of economies of scale that reduce vehicle production costs plus higher petroleum prices make these vehicles financially attractive to mainstream buyers.

Based on the following, this report does not conclude that a lack of publicly available charging stations will hinder purchases of PHEV/ZEV vehicles, so this carbon emissions reduction measure does not include incentives for charging station development.

- City of Tucson's participation in the EV Project managed by Ecotality USA.

- Projections by vendors that owners of commercial charging stations will obtain favorable return-on-investment rates; and

- The likelihood that vehicle fleets and citizens using PHEV/ZEV vehicles will provide their own charging infrastructure; and

- The likelihood that people with driving needs greater than the range of a ZEV will avoid purchasing ZEVs. They will instead purchase regular petroleum vehicles or PHEVs with typical vehicle ranges. This minimizes the need for daytime charging stations, at least in the near-term.

Description of Measure:

This ZEV/PHEV incentive measure could be described through several performance metrics of its effectiveness compared to a "business as usual" case without City intervention. One of these measures needs to be chosen as the lead indicator.

- Achieve a xx% reduction of the City's GHGs inventory through greater vehicle fuel efficiencies.

- Achieve a yy% annual increase in City resident, business and fleet-owned vehicles that achieve an specific efficiency goal, such as 30 or 35 average MPG (or its equivalent).

- Achieve a zz% increase in new ZEV and/or plug-in hybrid purchases or conversions.

The core problem with each of these indicators is establishment of the "business-as-usual" case of what is likely to occur without City intervention. The ZEV and PHEV markets are frontier markets with no historic precedents from which to draw reliable predictions.

A 2010 market prediction report by J.D. Power[13] projected slow growth of ZEVs in the US to 2020 for various reasons, particularly their high cost. Its surveys showed that although 17% of people initially express interest in a ZEV, the interest shrinks to 5% when they are informed of the $15,000 additional purchase price. The purchase barriers include the following (in parentheses are the % of survey respondents giving it as a reason for "lack of interest"; only the top three reasons were reported):

- Purchase cost premium (37%)

- Limited range (17%)

- Costs of ownership, including perceptions of continued electricity price increases or high costs of recharging (10%)
- Reduced power and performance, especially in hilly areas
- Battery charging infrastructure and length of battery recharging time
- Electricity-generation emissions (noted to be of interest only to strong green buyers)

The J.D. Power report predicts that while the US market for hybrid-electric vehicles, including PHEVs, will steadily grow to 1.67 million units by 2020 (nearly 10% of the US new vehicle market), ZEVs will grow only to 107,000 units by 2020, less than 1% of the new car market, with initial rapid growth to 2014 leveling off at about 80,000 units total for the rest of the decade.

The need for financial incentives for ZEVs and PHEVs is validated by consumer research in 2009 from the University of Michigan, which asked consumers about their willingness to pay extra for a vehicle obtaining 75% fuel savings over a gasoline engine. At a $2,500 premium, 46% said they would be willing; at $5,000, 30% expressed willingness, and at $10,000, only 14%.[14]

The City of Tucson is a partner in the EV Project managed by Ecotality USA. The project is committed to accomplish the following:

- Open a network of electric vehicle charging stations by summer 2011 that includes 180 residential charging stations, 230 Level 2 "Blink" stations, and 10 DC Fast Chargers.
- Make 900 Nissan Leafs available to Phoenix- and Tucson-area owners starting in December 2010 at project roll-out. The vehicles are being marketed to Tucson-area owners with a potential free home charger installation, but no other purchase incentives.

The "business as usual" scenario also includes the State of Arizona's reduced licensing fee incentive for purchase of alternate fueled vehicles (AFVs), including electricity. The incentive reduces the annual licensing costs to negligible levels between $5 and $10, whereas comparable new petroleum-fueled vehicles (assuming $20,000 purchase price) will pay ~$1200 in licensing fees over the vehicle's first five years. The ~$1150 difference reduces the miles needed to breakeven for ZEVs, using the assumptions in the analysis above.

In summary, this report finds the "business as usual" ZEV scenario for Tucson for coming years to be characterized by:

- Adequate electric charging infrastructure
- Inadequate incentives to promote purchase of ZEVs, which will not be cost-competitive without them.

This report has selected the third option listed: a ZEV/PHEV deployment goal for the City/region that is triple the new car sales that would normally be expected to occur given the region's population (data used: Pima county light-duty vehicle registrations as a percentage of total US light-duty vehicle registrations, 0.21% of the US total) and predicted US ZEV/PHEV sales estimates by J.D. Power.

This analysis uses J.D. Power's projections for US sales of ZEVs and hybrid-electric vehicles. It assumes that 5% of hybrid electric vehicles purchased in the US are PHEVs, and the remaining 95% are gasoline or diesel hybrids that do not use the electric grid (today's hybrids). J.D. Power predicted 1.67 million hybrid sales and 107,000 ZEV sales, in 2020.[15]

Westmoreland Associates recommends that the Tucson program not provide incentives for purchase of hybrids that are not primarily operating off of electricity from the grid, since they are surviving in the marketplace without incentives today.

The goal to 2020 is 3195 more ZEVs in the region than the business-as-usual projection, and 2640 more PHEVs.

Three options are offered for City consideration:

- Sales tax exemption at the point of sale of a ZEV, which could be applied to new and/or used vehicles
- Rebates (tax or sale price) that modify the consumer's costs of purchase
- Income tax credits for owners

The specific option chosen is not as important as the actual amount of cost reduction achieved, which must be enough to induce owners to purchase ZEVs or PHEVs.

Based on the $5,000 rebates offered by various states, which brings the initial cost of a Nissan Leaf to a tolerable breakeven at 72,000 miles at current gasoline prices, and assuming that the existing State of Arizona licensing incentive for AFVs continues to provide an ~$1,150 cost savings over five years that is seen as such by consumers, this report estimates that the Pima county region needs to offer an purchase incentive (rebate) worth $3,850 to ZEV/PHEV consumers.

Given the projected additional costs of $8,500 for the PHEV Chevy Volt compared to the Nissan Leaf, this incentive may not be enough to stimulate Volt sales, though it may stimulate sales of lesser-priced PHEVs expected to be marketed later in 2011.

A key question for regional decision-makers is whether any City/county/regional incentives for ZEV purchase should be given in addition to existing Federal rebates, or whether they should take effect only after eligibility for those rebates has closed, when potential consumers will face a much higher number of miles before breaking even on initial costs.

An alternative strategy for the City would be to help the State of Arizona establish a more meaningful state incentive (e.g. $5000 per vehicle) for electric vehicles (or in some cases, gasoline-electric hybrids), which 16 states have done as of November 2010.

The analysis that follows is focused on supplementing expected Federal rebates for the years 2011 to 2013 with $3,850 per vehicle such that total rebates are $12,500 for 441 vehicles.

To continue the program such that Pima County's share of ZEV/PHEV sales tripled the expected share (a total of 5835 vehicles)of the US market from 2011-2020, the total funds required at $3,850 per vehicle would be ~$22.3 million. With projected administration costs, the measure's costs are estimated to be $22.65 million.

A primary question for Pima County decision-makers is the source of the funds. This report recommends consideration of a "fee-bate" program in which fees are increased for some transportation options – or for other sources of greenhouse gases. These fees then fund the rebates.

The City or County's options will be limited by state statutes, but likely includes options such as auto registration fees or utility rights of way fee surcharges (used by City of Boulder, CO, to fund its Climate Action Plan). A vehicle parking/registration fee is used by the City of Chicago, where each vehicle registered to a City resident is required to pay a $50 annual parking fee.

Other options include: (1) a dedicated sales tax increase on non-AFV vehicle sales; (2) increased registration fees for non-AFVs; or (3) increased petroleum or fossil fuel consumption taxes.

Vehicle parking/registration fee scenario for Pima County:

Approximately 515,000 light-duty vehicles were registered in Pima County as of September 2010. A vehicle parking/registration fee of $10 per year would raise ~$5.15 million/yr. that could be used to subsidize ZEV/PHEV purchases in the region.

A $10 vehicle parking/registration fee for less than five years would raise the $22.65 million required for this measure. If decision-makers concluded that ZEVs/PHEVs would only require subsidies of $3850 per vehicle for five years, the vehicle registration fee could be halved to $5/year, or the duration of the fee reduced to slightly over two years.

Has the Measure been implemented elsewhere and with what results?:

City/county/regional fees to subsidize ZEVs/PHEVs have not been implemented.

Implementation scenario(s):

The goal of tripling (or more) business-as-usual deployment of ZEVs/PHEVs would need countywide or citywide adoption by governments, including a revenue source.

The implementation would ideally begin with 2011 purchases to help insure that the purchase incentive is combined with the Federal purchase rebate of $7,500, which is limited to initial purchases and may not be extended. Tucson may choose to increase the vehicle incentive beyond $3,850 when Federal subsidies expire so there is sufficient incentive for vehicle purchases at the desired rate of triple the expected share of the US market.

Energy/Emission analysis:

On a tailpipe emission basis, ZEVs and PHEVs operating on electricity will create near zero CO2 emissions attributable to the City of Tucson unless CO2 emitting operations within the City generate the electricity (some small emissions may result from battery operations or use of lubricants).

In this report, ZEVs are estimated to average 100 MPGe, PHEVs are estimated to achieve 80 MPGe, and a regular gasoline vehicle will achieve 30 MPG. Though approximately 7% of vehicle fuels used in Pima County are diesel, the analysis has been simplified by comparing ZEVs and PHEVs to gasoline only since gasoline vehicles are the most likely alternative for vehicle purchasers. The analysis assumes that a vehicle in the Pima County area is driven 12,000 miles per year and has a 10-year life.

Resulting CO_2 emission savings per vehicle per year compared to 30 MPG vehicle:

ZEV:	4,597 pounds CO2
PHEV:	4,104 “ “

Achieving the goal of tripling business-as-usual sales of ZEVs and PHEVs will result in the following additional deployment of vehicles and annual GHG savings; note that the "CO2 Emission Savings Beyond-BAU Vehicles" includes vehicles sold in previous years beyond the business-as-usual projections.

Table 3: CO_2 Emission Savings, Purchasing Incentives Program, in tCO2e

Year	ZEVs Sold Beyond BAU	PHEVs Sold Beyond BAU	CO_2 Emission Savings New Sales (tCO2e)*	CO_2 Emission Savings Beyond-BAU Vehicles (tCO2e)
2011	42	84	2,882	2,882
2012	168	147	7,372	10,254
2013	294	210	11,862	22,116
2014	336	252	13,820	35,936
2015	344	294	14,941	50,877
2016	353	315	15,625	66,502
2017	378	315	16,241	82,743
2018	403	336	17,318	100,061
2019	428	336	17,934	117,995
2020	449	351	18,781	136,777

* - assumes 6 months of savings in year purchased

The climate change impact summary below only gives the vehicles' GHG reduction credit for the year in which they operate, and assumes vehicles purchased 2011 through 2020 are still operating in Tucson in 2020.

Climate Change Impact Summary:

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	122 in 2012, 10,780 in 2020

Report authors recommend that City of Tucson also conduct a lifecycle emissions analysis to reflect the emissions generated to recharge ZEV/PHEV batteries, which are not included in the above calculation, which is based on tailpipe emissions only. While the City's main concern is GHGs emitted by City-based activities, programs such as this need to consider the full lifecycle of the sustainable technology being promoted such that overall global sustainability performance is enhanced.

Economic analysis:

Note: The economic analysis uses the lifetime of savings from an investment by a Tucson citizen to reduce climate change impacts, whereas the climate impacts section above only used the actual GHG savings each year to 2020.

Measure Costs

The local rebates to ZEV/PHEV buyers are assumed to be an average of $3,850 per vehicle, totaling $22.65 million over ten years. These costs, plus administrative costs of approximately 0.25 FTE or ~$250,000 over ten years, are assumed to be borne by vehicle-related fees, such as vehicle registration fees (as outlined in the scenario above) per vehicle in Tucson per year or other fee/tax concepts.

Depending on the concept chosen to raise funds for the rebates, the likely effect will be a small cost to the majority of Tucson citizens who are drivers in order to provide ZEV/PHEV purchase subsidies to a very small percentage of drivers (5,835 over ten years).

Because of this revenue neutral fee/bate concept, measure costs are assumed to be zero. There is an investment in the new ZEVs and PHEVs by their owners, but the investments are offset by savings greater than the premium cost compared to a gasoline vehicle.

The costs of purchasing a new vehicle are not included as a measure cost because it is assumed that people would not purchase a new vehicle unless they needed one or could afford one – i.e. the measure does not foster more new vehicle sales than would otherwise occur.

Measure Savings

Using the energy cost projections of Westmoreland Associates for Tucson from 2011 to 2031, we have estimated the total savings accruing to the owners of the 5,835 ZEV/PHEV vehicles purchased through the measure.

In this analysis, we have made the following assumptions:

- Vehicle purchase costs: The only reduction from retail costs of ZEVs ($32,500) or PHEVs ($35,000) is a $5,000 discount. The $5,000 is the result of the measure's $3,850 rebate combined with the existing Arizona vehicle registration savings for these vehicles of ~$1,250 over five years. The cost premium is a comparison of a ZEV or PHEV to a $20,000 gasoline vehicle.

- Vehicle fuel costs: The ZEVs are assumed to achieve 4 miles per kWh; the PHEVs 80 MPGe based on 4 miles per kWh in electric mode and 66 MPG in gasoline mode. The gasoline vehicle in the comparison achieves 30 MPG. These fuel efficiencies are divided into the assumption of 10,000 miles/year to achieve fuel purchases, which are multiplied by the Westmoreland Associates projected costs for Tucson of residential electricity and gasoline.

- Maintenance costs are same as regular gasoline vehicles (in fact, they are projected to be less, but this is as yet unproven).

- Fuel savings for expected vehicle life of 10 years are subtracted from the purchase premium after the $5,000 rebate to achieve net vehicle savings per owner. Fuel savings are estimated using 5,000 miles in the first year and 5,000 miles in the 11th year, reflecting that purchases in a given calendar year will likely average six months of ownership in that year.

- The vehicles remain in City of Tucson for their lifetimes (this will not be the case, but losses are unpredictable).

Projected lifetime of vehicle fuel savings (10 years):

ZEVs:

Purchased in 2011: $10,882
Purchased in 2020: $12,708

PHEVs:

Purchased in 2011: $10,457
Purchased in 2020: $12,391

Projected purchase cost premiums for ZEVs and PHEVs:

ZEV: $32,500 less $5,000 rebate less $20,000 cost of gasoline vehicle: $7,500
PHEV: $35,000 less $5,000 rebate less $20,000 cost of gasoline vehicle: $10,000.

Net savings per vehicle (lifetime fuel savings minus purchase premium after $5,000 rebates):

ZEVs:

Purchased in 2011: $3,382
Purchased in 2020: $5,208

PHEVs

Purchased in 2011: $ 457

Purchased in 2020: $2,391

If the Pima County incentive program reaches its goal over ten years of tripling BAU estimates and stimulates 3195 additional ZEV owners and 2640 additional PHEV owners, vehicle life ownership cost savings to Tucson owners are estimated to be: $19.65 million.

Net Economic Impact

The impact of the savings on Pima County's economy depends on the uses of the $19.65 million savings. Using a general economic development multiplier of 1.5, the gross economic impact would be a +$29.48 million through 2031, when the last of the vehicles purchased through the measure in 2020 are retired.

However, the reduction of expenditures on fuel would have some negative impact on the economy, though very little of petroleum fuel expenditures stay in the local economy because no petroleum is produced in Pima County. A reasonable estimate is a positive net impact of approximately +$9 million over ten years if the cost savings are spent locally such that the average local multiplier is 1.5.

Co-benefits (pros):

The co-benefits of tripling the BAU projections of ZEV/PHEV purchases should include:

- Providing better financial support to establishment of the electric vehicle charging infrastructure, which could result in additional net positive economic impacts if more ZEVs/PHEVs are purchased as a result of the better charging infrastructure.

- Positive economic development effects of the Pima County region having a stronger reputation for being a sustainability leader, which may influence the rapidly growing Cleantech industry to choose Pima county for job-creating business investments.

- Reduced air pollution from the increased fuel efficiencies and reduced tailpipe emissions of ZEVs/PHEVs.

Equitability:

This measure proposes providing $22.3 million in subsidies averaging $3,850 per vehicle to new vehicle purchases (i.e. one-time only per vehicle) of ZEVs and PHEVs over ten years. The equitability of this measure depends on the source of the funds.

Assuming that a person purchasing a *new* vehicle has above average income/wealth, a fee on all vehicles in Pima County that subsidizes new vehicle purchases would likely be regressive since people below average in income/wealth would be subsidizing only people who are above average.

However, if the funds were obtained by assessing fees only on the sales or registrations of new fuel-inefficient vehicles, or on inefficient vehicles valued over a certain $ amount (such as $15,000), the measure could become neutral or even progressive for Pima County / Tucson citizens.

Unintended consequences (cons):

The unintended negative consequences of this measure's success could include:

- Reduced economic activity due to the source of revenues to fund the fee-bate system. For example, if annual vehicle registration fees were collected or sales taxes increased, some people may find ways to register their vehicles or make sales-taxable purchases outside the City. However, the fees or sales taxes required are so small, this potential effect is likely to be insignificant.

- By fostering more consumer investment in efficient vehicles, the measure could divert investment capital away from other investments that are more financially efficient at reducing GHGs.

Endnotes

[1] Extrapolated by Westmoreland Associates from PAG GHG emissions statistics and projections to 2020 compared to vehicle miles traveled in the City of Tucson.

[2] Nissan press release, 22 November 2010, available at: http://www.autoguide.com/auto-news/2010/11/nissan-leaf-gets-official-99-mpg-epa-rating.html.

[3] The Motive Kestrel was designed by the manufacturer to achieve 6 miles per kilowatt hour (160 km range on 16 kWh battery), or the equivalent of 227 MPGe. It is half the weight of the Nissan Leaf's 3600 lbs., partly through use of a biocomposite body. See: http://green.autoblog.com/2010/09/02/motive-doesnt-bogart-cannabis-car-info-passes-more-us-more-det/. The Aptera is estimated to weigh 1700 lbs; its manufacturer is aiming for 200 MPG though a third party rated it at 164 MPGe; see: http://www.aptera.com/plugin.php.

[4] Nissan Leaf website, "How Far Can I Go," accessed November 2010. The website notes that the vehicle is designed for a 100 mile range.

[5] Peter Fairley, "Will Electric Vehicles Finally Succeed?", *Technology Review*, January/February 2011, pp 58-63.

[6] Argonne National Labs, GREET lifecycle energy and emissions modeling for 2008 models.

[7] Electric Power Research Institute and NRDC, "Environmental Assessment of Plug-in Hybrid Electric Vehicles, Vol. 1: Nationwide Greenhouse Gas Emissions, 2007, at: www.epri.com.

[8] Table 2 estimates are based on PHEVs averaging in between the price and performance expected from the Chevy Volt ($41,000 retail, 60 MPGe combined from 93 MPGe on batteries and 37 MPGe on gasoline) and PHEV Toyota Prius (est. $28,000 retail, testing at 90-100 MPGe combined); assuming 40% of driving done on batteries only as per EPA fuel efficiency estimates.

[9] US Department of Energy, Energy Information Administration, "Annual Energy Outlook 2010, with Projections to 2035," April 2010, at: www.eia.gov.

[10] US EIA, "Short-term Energy Outlook," 11 January 2011, at: http://www.eia.doe.gov/emeu/steo/pub/contents.html.

[11] The Electrification Coalition, "Electrification Roadmap – Revolutionizing Transportation and Achieving Energy Security," 2010, at: www.electrificationcoalition.org, p. 67.

[12] This projection is based on Tucson gasoline prices consistently being below the US average, and being ~5% below US average prices as of January 2011. The Westmoreland projections are for diesel to continue to be 16% above Tucson's gasoline price, also approximately the differential at the beginning of 2011.

[13] J.D. Power and Associates, "Drive Green 2020: More Hope Than Reality?", November 2010, at: http://businesscenter.jdpower.com/JDPAContent/CorpComm/pdfs/DriveGreen2020_110410.pdf.

[14] Richard Curtin etal., University of Michigan, "Plug-in Hybrid Electric Vehicles," 2009, at: http://www.sca.isr.umich.edu/documents.php?c=s.

[15] J.D. Power and Associates, "Drive Green 2020: More Hope Than Reality?", November 2010, at: http://businesscenter.jdpower.com/JDPAContent/CorpComm/pdfs/DriveGreen2020_110410.pdf.

Measure: Car Sharing Program (T18)

The City of Tucson facilitates establishment of a private (for-profit or non-profit) Car Sharing program beginning in 2012, becoming a "mature" system with 3,600 members by 2015.

Emission reduction potential by 2020:	5,000 tCO_2e / yr.
Percentage of goal (2012):	NA
Percentage of goal (2020):	0.2%
Total annual average implementation costs:	<$25,000 yr for parking signage
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e 2020:	Savings $3,456 / tCO2e
Net annual savings:	$17.3 million
Entity that realizes the financial return:	Car Sharing members
Equitability (progressive/regressive, income/revenue neutral, etc):	Progressive – enables lower transportation costs as % of income for lower income citizens
Potential unintended consequences:	Reduction in vehicle expenditures for vehicles and gasoline; slight reduction in public parking space inventory

Background information:

US citizens are accustomed to two forms of vehicle ownership: owning a vehicle, renting a vehicle by the day or week when traveling or temporary personal needs. In the past decade a third option has been developed by for-profit companies in various US and European cities: Car Sharing. Car sharing is rental of a vehicle available within walking distance by the hour, with rental rates structured to incentivize users to rent for 1-4 hours (otherwise, they will possibly pay more than rental for a day from a traditional rental agency).

In a typical car sharing system, a system member (typically paying $3 - $10 per month for membership privileges) reserves the car/truck of their choice via internet, walks or otherwise accesses the reserved vehicle, which is parked in a designated parking space only for its use on the street or in a private parking lot such as a shopping center, etc., uses their electronic membership card to unlock the doors (via internet connection) and access the keys inside.

The renter then uses the vehicle for the reserved time (unlimited mileage), returns it to the designated parking space, and relocks the doors. The internet-accessible control system checks the rental in and out, ensuring that only the renter that has reserved the vehicle is able to use it. If the vehicle needs more fuel (i.e. is below ¼ tank) the user uses the Car Share company's credit card to refuel it prior to reparking it. Car share companies will employ people to check for vehicle

Typical rental rates are $6-12/hour during "waking hours" of approximately 8 am to 10 pm; special discounts may be provided for overnight use (example: $34 overnight in Portland, OR). Rates depend on the costs of the car – small cars will be inexpensive and large vehicles will be expensive.

Similar to cell phone rates, Car Sharing companies offer lower hourly rates to heavy users if the member makes higher monthly payments (Example: a Zipcar member in Portland, OR paying $25 per month can save $3-$4.50/hr on regular rates).[1]

The Car Sharing industry began with local start-up companies, and has seen some consolidation amongst city systems moving toward national systems. Hertz, the world's largest rental company, has now entered the industry, starting with special agreements with institutions such as college campuses and military installations to make car sharing available to its stakeholders (college employees/students, military installation users, etc.).

Typical contributions by municipalities to Car Sharing systems are cooperation with establishing designated street parking spaces for the vehicles. No US car sharing system receives direct financial subsidies for its operations, though some industry pioneers received government grants to assist with start-up costs.

Like Bike Sharing, Car Sharing is a critical component of a sustainable mobility system for a region that allows people to achieve their desired mobility without owning a vehicle. Previously, people without owned cars were limited to what transit systems, friends/family, walking, use of an owned bicycle, and an occasional daily vehicle rental could provide.

Adding Car Sharing to this mix provides much greater mobility capability for a person that does not own a vehicle. One result can be increased use of transit, because transit fares are not an additional cost to the monthly cost of vehicle ownership, the vast majority of which are sunk costs in vehicle ownership rather than the marginal cost of vehicle use for a particular trip.

A typical US vehicle owner will pay $400-700 per month for its ownership, including purchase/depreciation, insurance, maintenance, and fuel, plus pay a productivity penalty for time spent cleaning, maintaining, fueling, purchasing, etc. Most users think only of fuel costs, approximately 10 cents per mile in regular gasoline vehicles, when deciding what mobility system to use for a particular trip instead of the approximately 50 cents per mile that includes all costs.

This marginal cost approach is not entirely irrational since 40 cents are sunk costs that the vehicle owner is paying whether the vehicle is used or not – making vehicle owners much less likely to use transit for particular trips since the slight cost differential of the transit cost from the marginal cost of vehicle fuel doesn't justify the inconvenience of transit.

However, if a person does not own a vehicle, which may be enabled by a Car Sharing system, the combination of Car Sharing membership/use with a transit pass, and possibly Bike Sharing, can save several hundred dollars per month, and promote transit or use of low-emissions vehicles (e.g. bikes, electric bikes, electric scooters, electrically-assisted personal mobility devices, etc.) as a primary rather than secondary mobility choices.

Zipcar, the world's largest car-sharing system, estimates that its members save $500 per month compared to car ownership.[2] Chicago's I-GO system estimates that its members save $5,000 per year.[3]

It has been estimated that a typical vehicle owner might spend 19 hours working to pay for, purchasing (including watching ads), and maintaining/cleaning their own vehicle for each one hour of use; if the one hour of use covers 60 miles, the overall average speed of the vehicle owner is 20 hours to achieve 60 miles = 3 miles per hour, the speed of walking.[4] For people who can use personal car-less mobility to meet their needs, substantial time and money savings can result.

Some of the benefits of a for-profit Car Sharing system can be achieved by individuals sharing ownership of a vehicle, reducing the sunk costs each must endure for individual ownership. In most states, this is precluded by insurance laws that allow auto insurance companies to not cover private vehicles that are cooperatively owned or otherwise "rented" to others.

However, California has addressed this problem through AB1871, which takes effect January 1, 2011, and San Francisco-based non-profit Car Share organizations have already launched a program to facilitate sharing of citizen-owned vehicles.[5]

It has been estimated that the existence of car sharing can reduce the parking spaces required by new residential developments ten percent, while could have indirect effects on Tucson's greenhouse gas emissions, depending on what the unneeded parking spaces are used for.[6] The City of Winnipeg recently negotiated inclusion of car sharing in a major residential development because of its multiple benefits to the City's sustainability goals.[7]

Zipcar, a for-profit US company, is the most successful car sharing system, being responsible for about 50% of car sharing services worldwide and serving 16 North American cities and over 100 university campuses including Arizona State University in the Phoenix area. It estimates that "10% of the US population is expected to adopt car sharing as their primary mode of transportation."[8]

Car Sharing systems can reduce the greenhouse gas emissions of a region in two primary ways:

- If the system provides more fuel-efficient and less carbon-emitting vehicles than car users would typically provide for themselves as owners, greenhouse gases will be reduced per mile.

- If the existence of the Car Sharing reduces total vehicle use because of monthly cost savings from avoidance of vehicle ownership (as outlined above).

Status Quo / Business as Usual:

Because city governments are partners with Car Sharing companies regarding designated parking spaces on city streets, the minimum action by the City of Tucson is to actively court and then cooperate with a Car Sharing company to establish a city-wide system. If the company believes it will achieve a profitable system in Tucson, the city's investment will only be the parking signs and other incidental expenses. This is the scenario used in the analysis below (i.e. zero City costs).

If Car Sharing companies do not believe they can earn a profit (or in the case of a non-profit company – break even), the City may consider subsidizing Car Sharing in order to obtain CO2 emissions reductions and the other benefits.

Models for subsidizing are found in the various agreements made by Car Sharing companies with universities where the university will typically guarantee a certain amount of revenue per car (similar to economic development efforts that sometimes will guarantee an airline a certain amount of revenue if the airline establishes new service to the city that will stimulate business investments or tourism).

Description of Measure and Implementation Scenario:

The City would facilitate development of a mature Car Sharing system with a Car Sharing company by the end of 2015, starting with operations in 2012.

Has the Measure been implemented elsewhere and with what results:

The 16+ cities in North America with city-wide Zipcar systems all have different histories of how the system was developed. Car Sharing companies are becoming more sophisticated and capitalized for rapid roll-outs of systems, especially if they have a foothold in the city via university or other institutional agreements, or in the case of Hertz' "Connect" system existing rental facilities that can serve as cost-effective ancillary services for members.

The industry is rapidly evolving, especially with the entry of Hertz into the industry. Car Sharing memberships increased dramatically in 2008 when gasoline prices spiked, which influenced people to reduce car ownership and mileage traveled when possible.

Energy/Emission analysis:

Greenhouse gas savings from more efficient vehicles:

Car Sharing companies have intentionally used vehicles that are more efficient than the typical mix of US vehicles, both in order to be a greener option for members, and to reduce fuel costs, which the Car Share company pays, relative to rental rates. These factors make it likely that a typical Car Share vehicle will achieve higher MPG and emit less GHGs.

In addition, because of their buying power, Car Share companies are already beginning to incorporate electric vehicles into their fleets with charging stations installed at vehicle locations. Examples include:

- Zipcar partnered with the City of San Francisco in February 2009 on a pilot-project to use PHEVs (retrofitted Toyota Priuses), based upon member surveys showing that 80% of members wanted more Alternative Fueled Vehicles (AFVs) in the car sharing fleet.[9]

- Chicago's I-GO system announced in July, 2010 that it would include 30 electric sedans in its car sharing fleet with charging stations provided through a Chicago Clean Cities Coalition grant by the end of 2011.[10]

Greenhouse gas savings from reduced vehicle use:

Zipcar estimates that each of the 6,500 shared vehicles in its fleet reduces the need for 15-20 private-owned vehicles; Chicago's I-GO system estimates 17 per member for a total of 3,200 since it began in 2002.

Zipcar surveys find that 90% of its members drive 5,500 miles or less per year, saving 219 gallons per year per member, or ~4300 pounds.[11] Montreal's Defi-Climat estimates that a typical car-sharing member will save 1200 kg. CO_2 per year (1.2 tCO_2e).[12]

Total estimated greenhouse gas savings:

Estimates of the total emissions reduction potential of a Tucson Car Sharing system will rely on estimates of the system's size and the estimates by existing car sharing systems of their GHG impacts. I-GO estimates that its system, 210 vehicles, creates GHG emissions savings of 25,000 tCO_2e/yr. from a combination of reduced driving and more efficient vehicles.

This analysis assumes that a mature city Car Sharing system in the City could be expected to attract 3600 members.[13] Conservatively estimating that each member would reduce their CO_2 emissions by 3000 pounds per year, the annual savings is estimated to be 5,000 tCO_2e/year starting in 2015.

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	5,000 tCO_2e

Economic analysis:

Measure Costs

Measure costs are estimated to be insignificant, though the City of Tucson will endure some expenses associated with the designation and signing of car share locations on city streets.

Measure Savings

Based on the estimates by Car Sharing companies that its members save ~$500 per month compared to car ownership, and an assumption that $100/month of the saved $500 per month would need to be dedicated to other forms of carless transportation (transit pass or fares, low-impact vehicles, etc.), 3600 Car Sharing members are estimated to save ~$17.3 million/yr. in transportation-related expenses.

If the program ramps up starting at 900 members in 2012, 1,800 in 2013, 2,700 in 2014 and 3,600 by 2015 through to 2020, estimated cost savings 2012 to 2020 are $~130 million.

Net Economic Impact

The economic impact on City of Tucson depends on what the Car Sharing members do with their savings, and the local economic multiplier associated with those expenditures. Models concerning what people will do with additional revenues have been shown to often be inaccurate (e.g. people have used tax cuts to save or pay off debt more than projected).

This report therefore assumes that the savings generated by GHG reduction measures have a local multiplier of 1.5, which is a typical multiplier used for economic impacts of new regional income from economic development (new primary jobs).

The economic impacts of the estimated $17.3 million savings to the Tucson region are therefore estimated as $26 million/yr.

However, the net impact will be slightly less (theoretically as little as $0) when the regional impact of the reduced expenditures on transportation is considered. The net impact is not likely to be zero because the local income multiplier for energy expenditures, especially petroleum (since it is not locally produced), is very low, and neither are new cars produced locally, meaning that only a small fraction of expenditure on a new car stays in the local economy.

The net impact is entirely dependent on the specific expenditure choices of the people achieving the transportation-related savings.

Co-benefits:

The co-benefits of a mature regional car sharing system are likely to be the following:

- Reduced driving by Car Sharing members can result in greater income productivity, and reduced healthcare problems/expenses
- Reduced traffic congestion, especially at peak hours, since Car Sharing members are more likely to use carless alternatives for their commutes.
- Reduced air pollution and roadway maintenance costs from reduced auto use.
- Increased numbers of transit customers, helping the financial viability of the region's transit system.
- Net positive economic impacts at little cost to local governments, unless government subsidies are required to support a mature Car Sharing system.
- More rapid increases in the fuel efficiencies of Tucson's light-duty vehicle fleet since Car Sharing companies may increase the use of highly fuel-efficient vehicles faster than the general population.

Equitability:

Car sharing membership requirements are not barriers for lower income people, and reduce transportation expenses compared to owning a vehicle – so car sharing is progressive from an equitability perspective.

Potential unintended consequences:

The unintended consequences of a mature regional car sharing system are likely to be the following:

- Reduction of vehicle sales and car-related purchases at local retailers, resulting in local government revenue losses from registrations.
- Reduction in local/state gasoline taxes or other revenues from vehicle use.
- Slight reduction in public parking inventory due to shared vehicles having dedicated spaces.

Endnotes

[1] Zipcar Portland Member Newsletter, September 2010.

[2] Zipcar website, "Green Benefits," accessed Nov. 2010 at: http://www.zipcar.com/it-it/greenbenefits.

[3] I-GO website, "Company Profile," accessed Nov. 2010 at: http://www.igocars.org/about/company-profile.

[4] Ivan Illich, *Energy and Equity*, 1970.

[5] Matthew Roth, "California's Personal Vehicle Sharing Law Could Diminish Need To Own a Car," SFStreetsBlog, 30 Sept. 2010, at: http://sf.streetsblog.org/2010/09/30/californias-personal-vehicle-sharing-law-could-diminish-need-to-own-a-car/.

[6] Ian Sacs, New York City Transportation Engineer, "Car Sharing Economies of Scale," 3 May 2009, at: http://www.planetizen.com/node/38233.

[7] Murray McNeill and Lindsay Wiebe, "City Drives Hard Condo Bargain – Conversion of Village Church Hinges on Car-share Deal," Winnipeg Free Press, 5 April 2009, at: http://www.winnipegfreepress.com/business/City-drives-hard-condo-bargain-44292562.html.

[8] Zipcar website, "Green Benefits," accessed Nov. 2010 at: http://www.zipcar.com/it-it/greenbenefits.

[9] Zipcar press release, "zipcar launches plug-in hybrid electric vehicle pilot program in san francisco," 18 February 2009, at: http://zipcar.mediaroom.com/index.php?s=43&item=5.

[10] Jon Hilkevitch, "I-GO to add all-electric cars in 2011," *Chicago Tribune*, 26 July 2010.

[11] Zipcar website, "Green Benefits," accessed Nov. 2010 at: http://www.zipcar.com/it-it/greenbenefits.

[12] Evelyn Reid, "Montreal, Defi-Climat and Global Warming: Fight Global Warming On The Road, About.com at: http://montreal.about.com/od/gettingaroundtown/tp/montreal_defi_climat_cartravel.htm, accessed Nov 2010.

[13] Car Sharing systems aim for 18 members per vehicle. A mostly mature system in Portland, Oregon has about 250 vehicles. The estimate for Pima County uses 200 vehicles with 18 members per vehicle.

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Measure: Enhanced Energy Efficiency of the City of Tucson Vehicle Fleet (T3)

The City would develop a policy for continuous improvement toward maximum fuel efficiency in its fleet, with net carbon neutral operations as an ultimate goal. It would begin with a commitment that as each vehicle in the current City fleet reaches replacement age it be replaced by a vehicle achieving, at a minimum, the fuel efficiency of new US fleet CAFÉ standards for the year of purchase, estimated to be 30% efficiency savings per vehicle.

COT Summary:

Emission reduction potential in 2020:	1,051 tCO_2e
Percentage of goal (2020):	0.05%
Total annual average implementation costs:	$0
Entity that bears the costs of implementation:	NA
Cost/Savings per tCO_2e in 2020:	$820
Net annual savings in 2020:	$575,000
Entity that realizes the financial return:	City of Tucson; community
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	None

Background information:

The City of Tucson fleet is comprised of approximately 2,450 vehicles.[1] These vehicles are used for various city departments such as law enforcement, waste management, street service/maintenance, and a city motor pool (69 vehicles) used by several departments. Greenhouse gas emissions (GHGs) attributable to the City's fleet accounted for just over 8% of the emissions from City government operations in 2008.

City facilities dispensed 1,414,885 gallons of gasoline in 2010, down from 1,500,000 gallons of gasoline in 2005. The city also dispensed 1,251,788 gallons of diesel, including biodiesel, in 2010 vs. 1,200,000 gallons of diesel in 2005.

The Fleet Services Division has historically purchased approximately 225 new vehicles each year, auctioning off replaced vehicles. Although new fleet vehicle purchases have been greatly reduced due to recent budgetary constraints, they have not completely halted. Fleet acquisitions for FY09 were 181 vehicles, and 61 for FY10.

The City's Fleet Services Division had already begun reducing GHGs by using alternative fuels. As of 2008, 220 Flex Fuel (E85 = 0.72 GGE/gal E85) vehicles, 460 Biodiesel (B20 = 1.126 GGE/gal B20) vehicles, and 79 Compressed Natural Gas (CNG = 0.18 GGE/gal CNG, 0.27 GGE/gal CNG, 0.225 GGE/gal CNG) vehicles were then in use.[2]

Business-as-Usual:

In the absence of an aggressive policy towards a more fuel-efficient fleet, the projected rising costs of gasoline and diesel fuels could act as a drag on the City's ability to provide essential services, or at the minimum a reduction in vehicle miles traveled.

The City reported in early 2011 that its Fleet Services Division has suspended the distribution of biodiesel for over the road use.[3] This was due to complications with fuel delivery and a loss of federal government incentives. Currently only red biodiesel, limited for off-road vehicles, is in use. When and if these complications are resolved it is Fleet Services' intention to again resume the use of green (on-road) biodiesel in diesel-powered fleet vehicles.

The City Fleet fuel usage and charges for FY10 are as follows:

- Unleaded: 1,401,846 gallons for $3,360,959
- Diesel: 108,296 gallons for $282,486
- Red Dye Diesel: 26,731 gallons for $64,916
- Biodiesel: 939,934 gallons for $2,491,679
- Red Dye Biodiesel: 176,827 gallons for $454,019

- Premium Unl: 13,039 gallons for $33,525
- E85: 24,888 gallons for $52,906
- E85 (from UofA): 4,709 gallons for 10,639
- LPG: 3,572 gallons for $7,807
- CNG: 6,266 eqv gallons for $7,460.

The City's Fleet Service Division reports that there are no immediate plans or timeframes to establish a carbon neutral fleet. However, the Division does support and encourage the use of alternative fuels whenever and wherever possible.

The Division reports that it is constantly reviewing ways to conserve energy and reduce the fleets' impact on the environment. Recent efforts include the addition of an on-site propane dispenser. This has reduced travel and time required to refuel the City's on-site propane powered vehicles and it will also allow for the expansion of propane vehicles within the City fleet.

Another such effort was the re-configuration of the City's refuse collection vehicles from ten-wheeled units to six-wheeled units. This change has increased the load carrying capacity of these vehicles and should result in a reduction in required trips to and from the landfill. Preliminary results are a notable reduction in fuel, brake and tire costs.

We project that under a business-as-usual scenario, City of Tucson fleet emissions will rise from approximately 24,000 tCO2e in 2010 to 26,500 tCO2e in 2020 (rising with population growth and corrected for efficiencies due to rising CAFE standards.)

Under this business-as-usual scenario, City fleet acquisitions will benefit from the rising CAFE standards but only to the extent that significant new acquisitions are made each year and fuel inefficient stock is retired. Moreover, the CAFE standards represents a fleet average for the manufacturer, with some vehicles having greater and some lesser mileage efficiency that the average.

Without a commitment to meet or exceed the average CAFE standard, the fleet could conceivably see replacement vehicles with little or possible even lower efficiency gains that a vehicle being replaced.

Description of Measure and Implementation Scenario:

The measure recommends adoption of a policy that directs each general use replacement vehicle to the City's fleet to meet or exceed the minimum US-EPA City fuel rating (CAFE standard) for the year of purchase. Currently the CAFE standard is 27.5 miles per gallon (MPG). In 2016 the CAFE standard rises to 35 MPG and reaches 43 MPG by 2020.

The recent slowdown in fleet additions will at some point need to accelerate unless there is a contraction in the use of City vehicles for the delivery of City services. We project an opportunity through the remainder of the decade to replace, on average 150 vehicles per year. If these vehicles achieve an average of 8 miles more per gallon than the vehicles they replaced we should expect to see fuel efficiencies for these new vehicles increase by 23% in 2016 and 37% by 2020 – assuming that each new vehicle replace one rated at the 2012 standard of 27.5 mpg.

Has the Measure been implemented elsewhere and with what results?

Measures to reduce GHGs through use of alternative fuels have been implemented in many U.S. cities.[4] **New Orleans** has a city fleet comprised completely of alternative fuel vehicles (Flex-fuel). **Las Vegas** has 90% of the city fleet using alternative and renewable fuels.

Austin TX has implemented a Climate Action Plan calling for a Carbon Neutral City Fleet by 2020.[5] Austin's has a fleet of 4,400 vehicles, over half of which have been replaced with alternative fuel vehicles as of 2008.[6]

The **Government of American Samoa**, a U.S. Territory, has adopted a policy wherein every government vehicle purchase request shall first be for a hybrid vehicle in the specification for bid.[7] If a hybrid vehicle is not available, the vehicle must meet US-EPA class size specifications and meet or exceed all of the following:

1) Combine the benefits of gasoline engines and electric motors through the use of one of the following methods/technologies: regenerative braking, electric motor drive/assist, and/or automatic start/shut off;

2) Have a minimum USEPA City fuel rating of 35 mpg (EPA's 2016 CAFE standard); and

3) Have a maximum U.S. Department of Energy "Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model" (GREET) annual greenhouse gas emissions of 5 tons. The policy is intended to serve as a market pull for getting higher efficiency vehicles imported to the Territory.

Energy/Emission analysis:

Westmoreland Associates has assumed that City fleet management policies combined with rising fuel efficiency of comparable models could create an average of 30% efficiency gains for 1,350 vehicles between 2012 and 2020, based on an annual replacement of 150 vehicles/yr.

We have also assumed that

(1) These general use fleet vehicles are driven 10,000 miles per year;
(2) Vehicles have a ten-year life;
(3) The savings in the year of purchase are equivalent to one-half of one year; and
(4) All vehicles are operated on gasoline and in 2011 achieved an average of 25 MPG.

Climate Change Impact Summary in tCO_2e

COT 1990 Citywide GHG emissions (baseline):	5,461,020 tCO_2e
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	1,051

Economic analysis:

Measure Costs

This economic analysis assumes that more efficient vehicles are not more costly than less efficient vehicles. The experience of the past decade is one of continued improvement of MPG in general use vehicles without expensive technologies such as hybridization. More efficient vehicles are frequently less expensive than standard vehicles, such as subcompact designs.

Measure Savings

The analysis is based on the gasoline prices projected for Tucson 2012-2030 by Westmoreland, based on prices being 5% below US projections of the Electrification Coalition to 2020, then rising 2.4% per year as predicted for consumer energy prices by the US EIA.

Gasoline costs saved by the City fleet budget are projected at $574,775 in the year 2020. From 2012 to 2020, savings total ~$2.84 million. Over the lifetime of the vehicles, fuel savings are projected at $6.66 million.

In 2020, the savings per tCO_2e is ~$820.

Net Impact

The economic impact of energy saved in the City of Tucson is projected to have a multiplier effect of 1.5 on the Tucson economy because energy, especially gasoline, has a small multiplier effect because of very little value added in the City.

The multiplier effect in 2020 is projected to be ~$862,000. The accumulated impact from 2012-2020 is projected to be ~$4.26 million. Over the 10-year lifetime of the vehicles, the economic impact is projected to be ~$10 million.

Co-benefits:

Over the lifetime of an increasingly energy-efficient fleet, the City will be taking a leadership role within the community in the transition to next generation transportation technology. Long-term fuel cost savings will help ease City operational expenses and allow funds to be directed to other pressing community needs.

Equitability:

Improving the fuel efficiency of the City vehicle fleet will have economic benefit to all taxpayers who now support the costs of City government operations.

Potential unintended consequences:

There appears no downside to the investment by the City in increasingly fuel-efficient vehicles at a time of tight current and future budgets and rising fuel prices.

Endnotes

[1] City of Tucson Fleet Services Division. http://ci.tucson.az.us/generalservices/fleet/index.html.

[2] City of Tucson - The Office of Conservation and Sustainable Development, 2008 - 2009 Sustainability Report, page 12. http://www.tucsonaz.gov/ocsd/docs/CMS1_035184.pdf.

[3] Communication with Tony Leon, Fleet Equipment Specialist, City of Tucson. January 2011.

[4] Sustain Lane, *Top 10 Alternative Fueled City Fleets*. http://www.sustainlane.com/reviews/top-ten-alternative-fueled-city-fleets//SD9V13Y7UBPSJ4IC7MYJ4F92WQ9H.

[5] Austin Climate Action Program - Municipal. http://ci.austin.tx.us/acpp/municipal_plan.htm.

[6] Austin Climate Protection Plan, 2008 update. http://www.ci.austin.tx.us/acpp/downloads/acpp_update_08apr.pdf.

[7] American Samoa Government. http://americansamoa.gov/News09/pr0903211.htm.

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Measure: Intersection Roundabouts (T13)

Plan, design and construct three roadway roundabouts in lieu of signalized intersections at candidate locations with the most favorable traffic and site characteristics based on successful roundabout projects elsewhere in the region or State.

Emission reduction potential by 2020:	987 tCO_2e / yr.
Percentage of goal (2012):	NA
Percentage of goal (2020):	.04%
Total annual average implementation costs:	0
Entity that bears the costs of implementation:	NA
Cost/Savings per tCO_2e:	Savings $1254 / tCO2e
Net annual savings:	$0.495 million
Entity that realizes the financial return:	Tucson motorists (99.6%) and City of Tucson (0.4%)
Equitability (progressive/regressive, income/revenue neutral, etc):	Likely progressive since fuel savings are a higher % of lower income household disposable income.
Potential unintended consequences:	Initial resistance

Background information:

The modern roundabout is a circular intersection with design features that promote safe and efficient traffic flow. At roundabouts in the United States, vehicles travel counterclockwise around a raised center island, with entering traffic yielding the right-of-way to circulating traffic. In urban settings, entering vehicles negotiate a curve sharp enough to slow speeds to about 15-20 mph.

Within the roundabout and as vehicles exit, slow speeds are maintained by the deflection of traffic around the center island and the relatively tight radius of the roundabout and exit lanes. Slow speeds aid in the smooth movement of vehicles into, around, and out of a roundabout. Drivers approaching a roundabout must reduce their speeds, look for potential conflicts with vehicles already in the circle, and be prepared to stop for pedestrians and bicyclists. Once in the roundabout, drivers proceed to the appropriate exit, following the guidance provided by traffic signs and pavement markings.

Roundabouts are appropriate at many intersections, including high crash locations and intersections with large traffic delays, complex geometry (more than four approach roads, for example), frequent left-turn movements, and relatively balanced traffic flows. Roundabouts can be constructed along congested arterials, in lieu of road widening, and can be appropriate in lieu of traffic signals at freeway exits and entrances.

Roundabouts are not appropriate everywhere. Intersections that may not be good candidates include those with topographic or site constraints that limit the ability to provide appropriate geometry, those with highly unbalanced traffic flows, and isolated intersections in a network of traffic signals.

Status Quo / Business as Usual:

Absent a proactive policy to begin adding roundabouts beyond the few which are now in place or planned, Tucson motorists will miss opportunities for sharing the multiple co-benefits (energy and emissions savings, cost savings, improved productivity, increased safety, etc.) of roundabouts compared to signalized intersections.

Description of Measure and Implementation Scenario:

In the Tucson area, three roundabouts have been proposed along the Silverbell Road improvement project, at the intersections of Grant Road, Ina Road, and Ruthrauf Road. This measure consists of three additional roundabouts either to replace existing intersection controls or to substitute for conventional intersection designs in new or significantly modified intersections in the first implementation year (may depend on requirements of TDOT/ADOT design and construction schedules).

Has the Measure been implemented elsewhere and with what results:

The first modern roundabouts in the United States were constructed in Nevada in 1990. Since that time, although a precise number is not available, approximately 2,000 have been built. By comparison there are about 20,000 roundabouts in France, 15,000 in Australia, and 10,000 in the United Kingdom.

Thirty-one States in the U.S. have active programs to construct roundabouts.[1] Three years ago, Arizona had two roundabouts, now it has around 17, with 23 more under construction according to the Arizona Department of Transportation. Modern roundabouts in New York tripled since 2006, from 16 to 53.[2]

Several studies conducted by the Insurance Institute of Highway Safety and others have reported significant improvements in traffic flow following conversion of traditional intersections to roundabouts. A study of three intersections in Kansas, Maryland, and Nevada, where roundabouts replaced stop signs, found that vehicle delays were reduced 13-23 percent and the proportion of vehicles that stopped was reduced 14-37%.[3]

A study of three locations in New Hampshire, New York, and Washington, where roundabouts replaced traffic signals or stop signs, found an 89 percent average reduction in vehicle delays and a 56 percent reduction in vehicle stops.[4]

A 2005 Insurance Institute study documented missed opportunities to improve traffic flow and safety at 10 urban intersections suitable for roundabouts where either traffic signals were installed or major modifications made to signalized intersections.[5] It was estimated that the use of roundabouts instead of traffic signals at these 10 intersections would have reduced vehicle delays by 62-74 percent. This is equivalent to approximately 325,000 fewer hours of delay on an annual basis.

Energy/Emission analysis:

A Washington State Department of Transportation study determined that one gallon of fuel is saved per 365 vehicles moving through a roundabout per day.[6] Applying this average to three planned roundabouts along Silverbell Road from Grant Rd. to Ina Rd results in a gasoline savings of 109,000 gallons/year based on projected traffic flows.[7]

A second opportunity for energy savings occurs n the elimination of electrical service to stoplight and pedestrian signals. For the three roundabout locations noted above, and using Energy Star criteria for signalization, the estimated energy savings from substitution of traffic signals with roundabouts is approximately 19,450 kWh / year.[8]

Thus, for every three roundabouts installed in lieu of traffic signals at locations with traffic flows similar to those in the proposed Silverbell Road improvement project, there is an energy savings of 109,000 gallons of gasoline and 19,450 kWh of electricity per year.

Over a one-year period with the energy savings identified above for a three-roundabout project, the GHG emission reductions attributable to the project will be:

> 109,000 gallons / year x CO2 emissions / gallon of vehicle fuels (93% gasoline; 7% diesel) = 969 tCO2e / year.
> 19,450 kWh / year x 2.0 pounds / kWh = 17.6 tCO2e / year.
>
> TOTAL: 987 tCO2e / year

Assuming that this initiative does not begin to realize benefits until after 2012, we project eight years of cumulative savings through 2020 of 7,896.

Climate Change Impact Summary (in tCO_2e):

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure in 2020:	987

Economic analysis:

The safety, operational, and environmental benefits of specific roundabouts can be quantified and compared to the initial construction and ongoing maintenance cost over the life cycle of the roundabouts. While initial construction costs might be higher for a roundabout in a retrofit situation (construction costs are often comparable to signalized intersections in new installations), the roundabout's ongoing maintenance is often cheaper than for signalized intersections, as there is typically no signal hardware to power, maintain, and keep current in terms of signal timing.

Finally, while many factors influence the potential service life of a roundabout (types of construction materials, weather conditions, traffic conditions, growth in the area, etc.), roundabouts can often serve for longer periods of time between major upgrades (repaving, reconstruction, etc.) than comparable signalized intersections.[9]

In a report covering roundabout construction in Alaska, results found that modern roundabouts are usually less expensive than traffic signals. Roundabouts did not require expensive signal equipment or maintenance of that equipment. In Anchorage, the initial construction cost of a roundabout was approximately equal to the initial construction cost of a signal. However, maintaining signals costs Anchorage taxpayers approximately $15,000 per year for each signal. Over the long run, modern roundabouts proved much less expensive than traffic signals.[10]

An example based on the 3-Roundabout Silverbell Road Improvement Project: Cost of roundabouts v. cost of signalization:

> We assume construction cost parity between planned roundabouts and a signalized intersection alternative. Therefore, there is no net cost per ton of GHG reduced.
>
> a) Fuel cost savings to drivers: 109,000 gallons x 20 years x Tucson fuel prices 2013-2032 (projected by Westmoreland Associates) are: $9.86 million, or an average of $493,000 / yr.[11]
>
> b) Electricity cost savings to the City Department of Transportation CDOT: 19,450 kWh/year x TEP rate for traffic signal electricity[12] = $36,000 or an average of $1800 / year.
>
> **Total Economic Benefit: $9.9 million over 20 years, not including auto accident reduction costs and productivity benefits from reduced congestion.**

The savings per tCO2e is $9,900,000 divided by 7,806 = $1254.

The benefits accrue to the City in the form of electricity savings, and to drivers in fuel savings. Assuming a multiplier effect of 1.5, the positive economic impact of this measure over 20 years is estimated at $14.85 million.

Co-benefits:

Several features of roundabouts promote safety. At traditional intersections with stop signs or traffic signals, some of the most common types of crashes are right-angle, left-turn, and head-on collisions. These types of collisions can be severe because vehicles may be raveling through the intersection at high speeds.

With roundabouts, these types of potentially serious crashes essentially are eliminated because vehicles travel in the same direction. Installing roundabouts in place of traffic signals can also reduce the likelihood of rear-end crashes and their severity by removing the incentive for drivers to speed up as they approach green lights and by reducing abrupt stops at red lights. The vehicle-to-vehicle conflicts that occur at roundabouts generally involve a vehicle merging into the circular roadway, with both vehicles traveling at low speeds – generally less than 20 mph in urban areas.

A 2001 Insurance Institute study of 23 intersections in the United States reported that converting intersections from traffic signals or stop signs to roundabouts reduced injury crashes by 80 percent and all crashes by 40 percent.[13]

Similar results were reported in another study: 75 percent decrease in injury crashes and a 37% decrease in total crashes at 35 intersections that were converted from traffic signals to roundabouts.[14] When safety factors go up, societal costs generally decrease.

Another co-benefit of roundabouts is that they can enhance roadway aesthetics by providing landscaping opportunities.

Lost driver productivity would be significant, based on the Insurance Institute example above, and suggests a savings of 32,500 driver-hours annually per roundabout.[15]

Equitability:

This measure is neutral in its costs and benefits to drivers of all income categories from the standpoint of fuel savings. Benefits of reduced delays will also be shared equally among all roadway users.

Potential unintended consequences:

Drivers may be skeptical, or even opposed, to roundabouts when they are proposed. However, experience demonstrates that driver opinions change quickly once they become familiar with roundabouts. An Insurance Institute study in three communities where single-lane roundabouts replaced stop-sign controlled intersections found 31 percent of drivers supporting the roundabouts before construction compared with 63 percent shortly after.[16]

Another study surveyed drivers in three additional communities where roundabouts replaced stop signs or traffic signals.[17] Overall, 36% of drivers supported the roundabouts before construction compared with 50% shortly after.

Follow-up surveys conducted in these six communities after roundabouts had been in place for more than one year found the level of public support increasing to about 70% on average.[18]

Endnotes

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[1] Insurance Institute for Highway Safety.
http://www.iihs.org/research/qanda/roundabouts.html

[2] "Green." The New York Times, December 30, 2008.
http://green.blogs.nytimes.com/2008/12/30/roundabouts-efficient-or-annoying/?scp=1&sq=roundabouts%202008&st=cse

[3] Retting, R.A. Luttrell, G.; and Russell, E.R. 2002.Public opinion and traffic flow impacts of newly installed modern roundabouts in the United States. ITE Journal 72:30-32, 37.

[4] Retting, R.A.; Mandavilli, S.; Russell, E.R.; and McCartt, A.T. 2006. Roundabouts, traffic flow, and public opinion. Traffic Engineering and Control 47:268-72.

[5] Bergh, C.; Retting, R.A.; and Meyers, E.J. 2005. Continued reliance on traffic signals: the cost of missed opportunities to improve traffic flow and safety at urban intersections. Arlington, VA: Insurance Institute for Highway Safety.

[6] "Hot or Not: Roundabouts." The New West Magazine. February 11, 2008.

[7] http://dot.ci.tucson.az.us/projects/stone/pdfs/roadimp.pdf

[8] http://www.energystar.gov/ia/partners/product_specs/eligibility/traffic_elig.pdf

[9] "Roundabouts: Technical Summary." Federal Highway Safety Administration. Office of Safety, FHGWA-SA-10-006.
http://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa10006/

[10] "Welcome to Alaska Roundabouts."
http://www.alaskaroundabouts.com/mythfact6.html

[11] Assumes the existing vehicle fuel mix of 93% gasoline and 7% diesel, according to Pima Association of Governments.

[12] The TEP traffic signal rate is $.07 kWh, which is assumed to increase with all other electric rates at a rate of 2.4% per year.

[13] Persaud, B.N.; Retting, R.A.; Garder, P.E.; and Lord, D. 2001. Safety effect of roundabout conversions in the United States: empirical Bayes observational before-after study. Transportation Research Record 1571:1-8.

[14] Eisenman, S.; Josselyn, J.; List, G.; Persaud, B.; Lyon, C.; Robinson, B.; Blogg, M.; Waltman, E.; and Troutbeck,R. 2004. Operational and safety performance of modern roundabouts and other intersection types. Final Report, SPR Project C-01-47. Albany, NY: New York State Department of Transportation.

[15] Bergh,C. op cit.

[16] Luttrell, G.; and Russell, E.R. 2002.Public opinion and traffic flow impacts of newly installed modern roundabouts in the United States. ITE Journal 72:30-32, 37.

[17] Retting, R.A.; Mandavilli, S.; Russell, E.R.; and McCartt, A.T. 2006. Roundabouts, traffic flow, and public opinion. Traffic Engineering and Control 47:268-72

[18] Retting, R.A.; Kyrychenko, S.Y.; and McCartt, A.T. 2007. Long-term trends in public opinion following construction of roundabouts. Transportation Research Record 2019:219-24.

Measure: Bike Share (T19)

Integration of a bike share program totaling 600 bikes into citywide multi-modal transportation system. The measure should be implemented in such a way to compliment current public transportation systems and the UA bike share program.

COT ARRA RFP Summary:

Emission reduction potential by 2020:	921 tCO_2e
Percentage of goal (2012):	0.05%
Percentage of goal (2020):	0.04%
Total annual average implementation costs:	$205K
Entity that bears the costs of implementation:	Public or private (see below for examples)
Savings per tCO_2e:	$520 / tCO_2e
Net annual savings:	$479K
Entity that realizes the financial return:	NA
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	See below

Background information:

Bike sharing is a system that facilitates short-term rental of pedal bicycles from one destination to another. According to the MWCOG application for grant funds for a region-wide bike-sharing program for the Washington DC metro area,

> "*By promoting bicycling for short trips of less than 3 miles, which currently are 17% of all commute trips, and 30% of non-work trips, and for the "last mile" of longer transit trips, bike sharing maximizes existing infrastructure by extending the reach of rail and bus transit in an effective, innovative, and low-cost way*."[1]

The system can be a valuable component of creating personal car-less mobility for Tucson residents and visitors, i.e. a system that maximizes a person's mobility through several options such as car or bike sharing, ridesharing and transit systems.

Bikes are rented and returned at automated kiosks and can be turned in to any other kiosk in the system. The system might be owned and operated by a municipal government, a non-profit organization or a for-profit company. The kiosks' small electricity needs (locking and unlocking bikes and internet access) are provided by the electric grid, solar panels or both; electricity needs increase if electric bikes (part of the bike-share system or privately-owned) are recharged at the kiosk.

Rental charges are structured to promote short-term use of the bike by increasing hourly costs for longer rentals. Typical user charges by US systems are ~$2-7 per hour including membership costs.[2] All of the *3rd Generation* programs initiated since 2008 have a tiered payment system ranging from single-use payment with credit card at the kiosk through yearly smartcard subscriptions.

Bike sharing is one way for communities to engage their constituents in a healthier, equitable, affordable, and more environmentally friendly mode of transportation that may be applicable to Tucson. Programs in cities like Denver, Washington D.C., and Minneapolis utilize sophisticated systems employ automated checkout systems, chip-enabled GPS tracking, mobile applications to track carbon offset generation, as well as better accounting and institutional practices to minimize theft and vandalism.

Business As Usual:

Currently, Tucson does not have a city-wide bike share program. Absent integration of such a program, Tucson commuters will miss out on the many co-benefits highlighted below and the City will miss out on a low-cost emission reduction potential.

Description of Measure and Implementation Scenario:

Given Tucson's growing bike-friendliness and dry climate, integrating a bike share program into citywide multi-modal transportation system could help to reduce local vehicular emissions while providing tangible co-benefits. This analysis researches three systems of varying sizes, with a focus on a particular size that may be applicable to the metropolitan Tucson area. A full analysis of the varying business models is outside the scope of this report.

The carbon analysis assumes that a Tucson program would be partially modeled after the Denver Bike Share pilot program or the Metropolitan Washington Coalition of Governments (MWCOG), meaning it would commence with 100 bikes available from 10 stations. It would complement the University of Arizona's Cat Wheels bike share program, not replace it.

The analysis further assumes that a Tucson program would grow over time to 600 bikes at 50 stations. However, the City could choose to skip the pilot project phase and begin with the 600-bike system in 2012.

Has the Measure been implemented elsewhere and with what results?:

Many US cities are at some stage of implementing bike-sharing programs. In the cases outlined below, Minneapolis, MWCOG and Denver, the pilot projects were successfully launched in 2008 and 2010. Funding for the pilot programs have come from a variety of sources including private foundations, corporate sponsorship, and Federal grants.

Details of these programs' full implementation are: [3] (or otherwise noted)

Minneapolis' Nice Ride Minnesota:[4]

The system was launched in June 2010 with 1,000 bikes and 65 stations. Start-up costs were $3.2M capital and an estimate of $1,300/bike/year for annual operations and maintenance of which 2/3 is covered by subscriptions and trip fee revenue with the balance covered by sponsorship. Its first 150-day riding season ended in early November with over 100,000 rides taken, 1,295 one-year subscriptions sold, nearly 30,000 one-day or one-month subscriptions sold, An end-of-season survey found that 77% of users already owned a bike and 89% used the bikes for transportation as opposed to recreation.

Denver's B-cycle:

Building on the success of the temporary bike share program set up for the Democratic National Convention in 2008, Denver Bike Share was established to continue bike sharing in the Denver area in spring 2010. The independent non-profit organization was developed by the City of Denver; a major private-sector partner is the Kaiser Permanente Healthcare System. Its first phase consists of 50 stations and over 600 bikes. The implementation costs were approximately $2M (approx. $3,333/per bike) with annual O&M costs projected to be $1.5M. Denver's B-cycle is projected to have year O&M expenses of $1.5M with revenue from "*user and member fees, grants and sponsorships of bike stations*" totaling $1.53M.[5]

MWCOG SmartBike:[6]

Through a 2010 application for a Transportation Investments Generating Economic Recovery (TIGER) grant, MWCOG has an ambitious 20-year plan for their bike share program. The pilot program began with 120 bikes with 10 stations funded through a 20-year advertising contract on bus shelters with Clear Channel Outdoors. The full implementation costs for a year 1 launch with 3,250 bikes is projected to be $12.0M for capital and $4.6M for O&M. The annual O&M costs are a function of the quantity of bikes ($1,400/bike which contemplates and 8% cost for vandalism and theft) and bike replacements every 5 years.

The University of Arizona's Cat Wheels program:[7]

The university's Cat Wheels programs makes bikes available at any of four garages plus the Campus Recreation Outdoor Adventure Center from 7:30 to 4:00 pm on weekdays. A single rental is good for 24 hours but bikes must be returned to their original home by end of business the following work day or a $10/day late fee applies. The program's 25 bikes are available at no cost to UA students or employees.

Energy/Emission analysis:

The GHG analysis will use a cost assumption of $3,441 per bike, which is an average of the per bike capital expenditure of Denver, MWCOG, and Minneapolis (actual per bike capital cost are $3,333, $3,700, and $3,200, respectively):

Description	***Input***	***Notes***
Average bike trip length	1.5 miles	From MWCOG
QTY of riders/bike/day	7	From MWCOG
gCO_2e/mi (light-duty)	319	Assuming annual 2% reduction due to CAFE, the 10-year AVG.
gCO_2e/mi (transit)	454	Converted from 1.0 lb CO_2e/mi
% of riders shifted from single occupant light-duty vehicles	20%	Assumptions from MN[8] and MWCOG[9]

% of riders shifted from transit users	20%	
% of riders shifted from ridesharing	15%	
% of riders shifted from walkers	30%	
% of recreational riders or wouldn't have taken trip at all	15%	
Pilot		
Quantity of Bikes	100	
Capital Costs	$341K	
Daily ridership (bikes * riders/day)	700	
QTY of trips per day (2 trips/rider)	1400	
VMT reduced per day (SOV)	420	
VMT reduced per day (transit)	420	
VMT reduced per day (rideshare)	315	
CO_2e avoided (VMT reduced per day * CO_2e/mile) / 1,000,000g/t * 365 * 10yrs	1,552	tCO_2e. Assumes a 10-yr life
Full Program		
QTY of Bikes	600	
Capital Costs	$2.05M	
Daily ridership (bikes * riders/day)	4200	
# of trips per day (2 trips per rider)	8400	
VMT reduced per day (SOV)	2520	
VMT reduced per day (transit)	2520	
VMT reduced per day (rideshare)	1890	
CO_2 avoided (in 2020)	921	tCO_2e

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline)[10]:	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	

2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Full Program		
Contribution of T19 Bike Share Measure (in 2020):	921	tCO_2e
2020 Contribution of T19 Bike Share Measure:	0.04	%

Economic analysis:.

This economic analysis is based on the following assumptions:

- A bike-sharing system's capital costs are spread over a ten-year lifetime for the kiosks and bikes. A pilot project of 100 bikes has capital costs of $341,111 and a full project of 600 bikes has capital costs of $2.05M. Interest charges on capital costs are zero (i.e. capital is provided as a government grant or private-sector investment rather than a loan).

- Operation and maintenance costs are assumed to be fully covered by user charges and other revenue sources.[11] Therefore, the annual net costs to citizens of the bike-sharing system are the capital costs divided by ten years.

- Each bike is used by an average of 7 riders 2 times per day with an average trip distance of 1.5 miles. Therefore, each bike travels 7,665 miles per year.

- Bike-share trips occur for the following reasons:
  - 20% are a substitute for a single-occupant light-duty vehicle trip achieving 26 MPG therefore emitting 0.77 pounds of CO_2e per mile.
  - 20% are a substitute for a transit bus achieving 1 pound of CO_2e per passenger mile, the City of Tucson's rate as of 2006.
  - 15% are a substitute for ridesharing in light-duty vehicle trips with the same emissions listed above.

Economic Results:

- Full program, 600 bikes and 50 stations, life of 10-years commencing 2012
  - Total costs to citizens: $2.05 million
  - Savings (from fuel): $6.84 million
  - Net savings over 10-year life of program: $4.79 million
  - Annual miles ridden: 4.60 million miles
  - Cumulative CO_2e savings: ***9,211 tCO_2e***
  - Net savings per ton of CO2e savings: ***\$520/tCO_2e***[12]

Co-benefits:

Many co-benefits exist in a bike share program. The MWCOG *Bike Sharing Cost Benefit Analysis* lists the following benefits:[2]

- Increased transit use
- Reduced transportation costs to households
- Public health improvement
- Increase traffic safety for cyclists b/c of critical mass
- Increased transportation access
- Congestion relief

Through the increased use of transit and reduced dependence on fuel, this measure should be in alignment with Tucson's other GHG adaptation measures.

Bike-sharing systems have the potential for increasing the use of personal bikes or electric bikes if they stimulate demand for bike-friendly infrastructure such as secure/covered storage, charging systems, shower/locker facilities, etc. at buildings. Some systems are designed to be grid-free, relying solely or partially on solar energy generated at the.

Equitability:

This measure is income neutral due to the transportation cost effectiveness of the program.

Potential unintended consequences:

As a result of increased bicycle transportation, some implementing communities project a small uptick in cycling accidents. Even in these situations, overall healthcare and auto-accident cost-benefit projections are net positive (for example, please see Works Cited 2). Finally, it is worth noting that during the first season of the Nice Ride Minnesota system resulted in only 2 accidents and zero injuries in over 100,000 rides.

Increased bike traffic can increase vehicle congestion unless bikes are given their own rights of way systems that minimize vehicle interactions – something that both bike and vehicles users desire. Congestion problems are somewhat reduced by use of electric bikes that will typically achieve speeds of 20 MPH without pedaling – which reduces the speed differential between bikes and vehicles.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] Metropolitan Washington Council of Governments, "A Regional Bike-sharing System for the National Capital Region," application for US DOT TIGER grant funding, August 2010.

[2] Denver's system charges include a membership fee to access a bike plus an hourly charge. Membership fees range from $5 for a one-day pass to $65 for annual membership. Charges range from no charge for less than 30 minutes to $6.60 for the fourth half-hour of rental (91-120 minutes) and $4.40 per additional 30 minutes. A one-hour rental 24 times per year would average $3.81 per hour; a one-hour rental 52 times per year would average $2.35 per hour. See: http://denver.bcycle.com/pricing.aspx. Nice Ride Minnesota also charges $5 for a one-day subscription and allows a 30-minute ride at no additional cost. Other charges are slightly different than Denver: $60 for one-year subscription; a total of $4.50 for a 90-minute rental and $6.00 per additional thirty minutes. A one-hour rental 24 times per year would average $4 per hour total costs; a one-hour rental 52 times per year would average $2.65 per hour. In both systems, a "casual" single-day user, such as a tourist, would pay $6+ for a one-hour ride.

[3] CityRyde, LLC. (2010, Sept 21). CityRyde-Products-Whitepapers. Retrieved Nov 13, 2010, from CityRyde: http://www.cityryde.com/what-we-do/products/whitepapers/

[4] Information obtained from website of Nice Ride Minnesota: www.niceridemn.org.

[5] http://blogs.westword.com/latestword/2009/05/denvers_bike-share_program_lau.php

[6] http://www.mwcog.org/transportation/activities/tigerii/documents.asp?COMMITTEE_ID=262

[7] Information obtained from website of Cat Wheels: https://parking.arizona.edu/bikeshare.

[8] Nice Ride survey results: http://appv3.sgizmo.com/reportsview/?key=102593-416326-6d13ea0276ea0822c9f59f4411b6c779

[9] Washington bike share pilot survey results: http://bike-sharing.blogspot.com/2009/06/washington-bike-sharing-survey-results.html

[10] PAG Regional Greenhouse Gas Inventory Addendum – 2009

[11] Transcript of interview with B-cycle CMO: http://www.bikewaycentral.com/2010/06/interview-andrew-davison-b-cycle-cmo-on.html

[12] Note the small increase in the normalized cost per tonne is due to the assumed 2% decrease in grams of CO_2e per mile driven by increased CAFE standards.

Measure: City of Tucson Telework Program (T2)

Design and adopt an expanded telework program for City employees that extends to 20% of the workforce and delivers fuel and cost savings, reduces emissions, and restores worker productivity lost to commuting while at the same time achieving City Department missions.

Emission reduction potential in 2020:	706 tCO_2e/yr.
Percentage of goal (2012):	0.04%
Percentage of goal (2020):	0.03%
Total annual average implementation costs:	$0
Entity that bears the costs of implementation:	City of Tucson
Cost/Savings per tCO_2e:	Savings $437/tCO2e
Net annual savings:	$309,000
Entity that realizes the financial return:	City of Tucson employees
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	Less productivity

Background information:

Telework refers to work performed outside of a traditional on-site work environment. Programs usually consist of work arrangements between employers and employees in which an employee regularly performs officially assigned duties at home or another place of convenience.

These can include working from a telework center, home office, or the conduct of a business virtually via the internet as well as simple flexible work schedules to avoid traffic congestions during peak commuting hours.

Telework programs have benefits of reducing vehicle miles traveled as well as associated emissions, time lost in commutes, and cost savings due to reduced fuel purchases.[1]

Status Quo / Business as Usual:

In the absence of an aggressive and expanded telework program, employees of the City of Tucson may miss opportunities to achieve energy and cost savings owing to telework benefits. In addition, the City may likely miss opportunities of its own to achieve increased workforce productivity that most often accompanies episodic teleworking of its workforce.

Description of Measure and Implementation Scenario:

The City of Tucson will design and adopt an expanded telework program for City employees that engages 20% of its telework-eligible workforce (estimated at 25% of the total workforce of ~5,300) to telecommute at least one day a week and pursue the necessary management steps to implement this policy. Full implementation occurs in year one of the program.

Has the Measure been implemented elsewhere and with what results:

The measure has been implemented across the United States, in government, academia, and the private sector.[2] Examples of positive energy savings, greenhouse gas reduction, and other benefits are attached to each program.

In one particular program, the U.S. General Services Administration[3] quantified the savings from engaging its HQ workforce (12,205), 85% of which were eligible for telework, at a participation rate (50%) in telework of one day per week. Telework trip-miles saved came to 4,735,146 single occupancy vehicle miles and fuel (gasoline) saved of 220,239 gallons. Using 2007 fuel costs at the time, the fuel savings amounted to almost $616,000.

In a more comprehensive evaluation of the public and private sector telework practice, the American Enterprise Institute (AEI) reports that per year, the average teleworker uses 339 fewer gallons of gas and saves $1,018 in commuting costs (based on $3.00/gallon gasoline national average).[4]

Energy/Emission analysis:

Taking the national average of 340 gallons of gasoline saved per year and lowering it to account for the reduced average commute time for Tucson workers[5], there will still be a projected savings of 300 gallons/telework employee/year.

There will also be energy savings to the City in the form of reduced operating costs in buildings less frequently occupied. At some point additional consolidation of office space may be possible creating permanent cost savings, some of it from lower energy expenses. These savings are not easily quantified at this time.

Assuming 25% of City employees are telework-eligible, and 20% of those are engaged in a telework program, the total number of staff initially teleworking one-day a week would be 265. Annual fuel savings generated by this number of teleworkers over one year would be 79,500 gallons.

Greenhouse gas savings from 265 employees of the City teleworking one day of week for one year equates to: 706 tons.

Climate Change Impact Summary in tCO_2e:

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure each year:	706

Economic analysis:

The cost of administering a telework program for the City may would likely be negligible and should not be expected to exceed the savings form reduced building energy use and other savings especially should workplace consolidation and other facility savings be possible.

Using the Westmoreland Associates Tucson vehicle fuel price projections, and the existing mix of vehicle fuels as 93% gasoline and 7% diesel, the annual savings are projected to average ~$309,000. Total savings to 2020 is ~$3.1 million.

The dollar savings per tCO_2e saved through 2020 is $437.

The projected economic impact using the 1.5 multiplier is ~$4.63 million.

Co-benefits:

The General Services Administration[6] and the AEI[7] have each catalogued a range of co-benefits that accrue from telework. These include:

- Improved employee job performance
- Reduced absenteeism
- Maintain COOP in the face of emergency disruptions
- Improved moral and employee retention
- More accommodating to persons with disabilities
- Reduced demand for office space and facility operating costs, and
- Optimal use of technological advances

As the City demonstrates through this expanded telework program that multiple benefits accrue to itself and its workforce it may well become a model for private and non-profit sector (Raytheon, Davis-Monthan AFB, University of Arizona, etc.) telework initiatives with much larger cost savings, energy and emissions reductions potential may be implemented, further reducing Tucson congestion.

Equitability:

Due to the inability of certain job tasks being performed outside of the conventional work environment, not all job classifications may be determined eligible for telework. This may result in employee dissatisfaction issues if not addressed in some other manner to offset benefits of telework not available to all.

Potential unintended consequences:

There will always remain for the potential of a program such as telework to be abused by employees no longer in a traditional workplace setting with traditional workplace supervisory and peer relationships available. Also, some workers may not function well in a telework situation and may self-select out of the opportunity to participate in such a program. Finally, there may be the perception that workers in a telework mode are abusing it. This will need to be addressed at the outset of any program via clear changes in management approaches, accountability expectations, and communications both across and outside the organization.

Endnotes

[1] http://www.teleworkexchange.com/teleworker-09-10h.asp

[2] Johnson, M., General Services Administration, "Telework boosts productivity, decreases carbon footprint," The Federal Times, 2010, at: http://www.federaltimes.com/article/20101031/ADOP06/10310307/

[3] U.S. General Services Administration and the Telework Exchange. "The Benefits of Telework." 2008. http://www.teleworkexchange.com/pdfs/The-Benefits-of-Telework.pdf

[4] Green, K.P.; Should the Government Expand Telework? 2010. American Enterprise Institute for Public Policy Research. No 2. http://www.aei.org/docLib/EEO-2010-8-No-2-g.pdf

[5] City-data.com. Tucson,AZ Houses and Residents. http://www.city-data.com/housing/houses-Tucson-Arizona.html

[6] U.S. GSA, op cit.

[7] Green, op cit.

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Measures outside Scope or With Negligible Benefits

- Warm Mix Asphalt (E1, E1b, E19a)
- Electricity Carbon Surcharge (E15)
- Mandatory Use of Green Concrete (G1)
- Measures Not Analyzed (G12_T4_T8_T9_T11_T17)

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Measure: Warm Mix Asphalt (E1, E1b, E19a)

This measure calls for the substitution for a lower GHG emissions form of asphalt (warm mix) for the more standard, hot mix, form.

Note: The 2010 update to the City's Greenhouse Gas Inventory does not include emissions from asphalt use in the City. Thus, this measure is not analyzed in the context of the City's 2012 or 2020 emissions reduction goals. There may still be cost and emissions reductions value in pursuing the substitution of hot mix with warm mix asphalt and this potential is discussed below.

Emission reduction potential by 2020:	1,420 tCO_2e/yr
Percentage of goal (2012):	N/A – not in inventory
Percentage of goal (2020):	N/A – not in inventory
Total annual average implementation costs:	$0
Entity that bears the costs of implementation:	N/A
Savings per tCO_2e:	$145
Net annual savings:	$61,000
Entities that realizes the financial return:	City of Tucson and private asphalt customers
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	Depends on durability of warm asphalt

Background information:

Warm mix asphalt (WMA) is an alternative to standard hot-mix asphalt, where different chemicals are used to allow asphalt to be made and applied at considerably lower temperatures of around 50-100 degrees F. Mixing and paving at lower temperatures translates to lower energy usage as well as lower volatile emissions in the paving process.

There are multiple WMA methodologies; at least 14 suppliers are currently marketing to the U.S. The WMA methodologies can be roughly grouped as those that use some type of organic additive or wax, those that use a chemical additive or surfactant, and those that use water for foaming.[1]

Description of Measure and Implementation Scenario:

We do not provide an implementation scenario relative to the City's emissions reduction goals. Use of warm instead of hot asphalt is a decision of the City's Transportation Department and the city's private asphalt customers.

Has the Measure been implemented elsewhere and with what result:

A commercial paving company first used Mead MestVaco's EVOTHERM (one of many warm mix asphalt technologies) in Escondido, CA in September 2009.[2]

At Boston's Logan Airport runways were resurfaced using warm-mix asphalt and this project was expected to result in the reduction of 3,600 tons of carbon dioxide compared to the use of hot mix asphalt.[3]

Energy/Emission analysis:

We did not conduct an emissions analysis relative to the City's 2012 goal as emissions from asphalt paving of road, parking, and other surfaces "were not included in either the Community or Government inventories. The inventory contents followed the format of the CACP model - energy use, transportation and waste, although if information was available, those emissions could be place in the "other" category. As per the design of the inventory, 1990-2008 data would be needed."[4]

However, using analyses contained in earlier work for the City by a University of Arizona student, the emissions savings potential of warm v. hot mix asphalt can be understood and considered in perspective to other measures being analyzed.

The approximate asphalt use in the United States is reported at 111.4 tons per 1,000 per capita.[5]

The Pima Association of Governments estimates that Tucson had a population of 546,549 in 2010. Using these values, Tucson asphalt use in 2010 would total 60,886 tons/year and may grow 1.89% per year (PAG population growth projection).[6]

Carbon dioxide emissions attributable to asphalt use have been reported by the National Asphalt Pavement Association, and amount to 0.023 tCO_2e per ton of hot mix asphalt.[7]

If Tucson uses 60,886 tons of hot mix asphalt per year for various purposes, the carbon intensity of this usage would total 1,400 tCO_2e/year.

Warm mix asphalt produces 20-40% less greenhouse gas emissions than does hot mix asphalt.[8] Using the mid-point of the 20-40% range, the savings from a complete conversion from hot mix to warm mix asphalt in Tucson would amount to .30 x 1,400 = 420 tCO_2e/year.

Climate Change Impact Summary in tCO_2e.

COT 1990 Citywide GHG emissions (baseline):	5,461,020
MCPA 7% reduction target for COT:	5,078,749
2012 BAU GHG emissions projection:	7,000,000
2020 BAU GHG emissions projection:	7,343,141
GHG emissions reduction to meet 7% goal (2012):	1,921,251
GHG emissions reduction to meet 7% goal (2020):	2,264,392
Contribution of this Measure:	NA – not counted in inventory

Economic analysis:

Measure Costs

There are no additional costs identified.

Measure Savings

The reported fuel savings from producing warm mix asphalt is typically 30-35%, which translates into an approximate cost savings of $1.00/ton or more.[9]

Therefore, for the total asphalt use in Tucson estimated at 60,886 tons/year, we estimate the City of Tucson's cost savings at $61,000/year.

The annual savings per tCO_2e would amount to ~$145.

Net Economic Impact

We do not apply the economic impact multiplier of 1.5 since asphalt has a strong local production component – so it is unlikely that the savings on asphalt would be spent in the local economy with a higher multiplier than asphalt. Net economic impact is estimated to be $61,000/yr.

Co-benefits:

Government and industry have identified multiple co-benefits of warm mix asphalt. They include:

1. Safer Environment For Employees (Emissions & Odors)
2. Reduced Greenhouse Gasses
3. Reduced Fuel Usage (Lowers Energy Costs 10-30%)

4. Compaction Aid
5. Can Pave In Cooler Weather And Still Obtain Density
6. Longer Haul Distances While Still Maintaining Workability
7. Extended Paving Season
8. Able To Pave Over Crack Sealant
9. Less Hardening Of Binder (Appearance & Longer Life)
10. Earlier Opening To Traffic[10]

Fuel savings on the WMA projects monitored thus far indicate that burner fuel savings of 20 to 35 percent are possible.

Equitability:

No significant effects.

Potential unintended consequences:

The use of coal-tar sealants on any asphalt surface, warm or hot mix, should be avoided due to increasing evidence of coal-tar toxicity. Asphalt pavement sealants are reported to provide "dramatically lower levels" of benzo(a)pyrene, a toxic chemical used in coal-tar sealants.[11]

Endnotes

[1] Asphalt Magazine. March 10, 2009. http://www.asphaltmagazine.com/singlenews.asp?item_ID=1679&comm=0&list_code_int=MAG01-INT.

[2] http://www.wesernemulsions.com/static/index.cfm?action=group&contentID=32.

[3] USA Today. 2009. “Clean landing: Boston airport lays green runway.” http://www.usatoday.com/travel/flights/2009-09-20-boston-logan-green-runway_N.htm.

[4] Communication with Ms. Susanne Cotty, Pima Association of Governments. January 10, 2011.

[5] Nation Master. November 2009. http://www.nationmaster.com/graph/ene_bit_asp_con_for_non_use_percap-consumption-non-uses-per-capita.

[6] Pima Association of Governments. Population Estimates. http://www.pagnet.org/RegionalData/Population/PopulationEstimates/tabid/582/Default.aspx.

[7] National Asphalt Pavement Association. July 2009. “Environmental Alert.” http://www.hotmix.org/index.php?option=com_content&task=view&id=449&Itemid=72.

[8] D’Angelo, J. et al. (2008) Warm Mix Asphalt: European Practice. US Department of Transportation. http://www.warmmixasphalt.com/submissions/68_20080223_FHWA-PL-08-007.pdf.

[9] Transportation Engineering and Road Research Alliance. June 2009. http://www.terraroadalliance.org/documents/terrafactsheet_wma_05.pdf.

[10] http://nwpma-online.org/resources/09Spring_WarmMixAsphalt_ShaunaTeclemariam.pdf.

11 “New doubts cast on safety of common driveway sealant.” Chicago Tribune. January 15, 2011.

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Measure: Electricity Carbon Surcharge (E15)

Pass by ballot a “clean energy and pollution reduction tariff” or raise City Utility tax rates to fund other GHG mitigation measures. For a discussion on tax-shifting to encourage energy reducing behavior change, please see this report’s appendices.

COT ARRA RFP Summary:

Emission reduction potential:	No direct reductions; Helps finance other mitigation programs
Percentage of goal (2012):	See Measures Funded
Percentage of goal (2020):	See Measures Funded
Total annual average implementation costs:	Minimal
Entity that bears the costs of implementation:	See Measures Funded
Cost/Savings per tCO_2e:	See Measures Funded
Net annual savings:	See Measures Funded
Entity that realizes the financial return:	See Measures Funded
Equitability (progressive/regressive, income/revenue neutral, etc):	The surcharge can be structured accordingly
Potential unintended consequences:	NA
Possible public revenue generation:	$21.895 million using Boulder’s tax rates

Background information:

Previous reporting to the City of Tucson Office of Conservation and Sustainable Development on "carbon taxing" largely misunderstood the implementation of such a measure in participating cities (ie, Boulder, Colorado). The International Council for Local Environmental Initiatives (ICLEI) Climate and Air Pollution Planning Assistant (CAPPA) model recognizes such programs primarily as a revenue generating activity for participating local governments. In their words:

> "*The emissions reductions associated with a local carbon tax will be those achieved through whatever programs are funded by the tax. Go to the … measures you will be using tax funds to implement to find emissions reductions from them. Depending on the structure of the carbon tax, it may also be a financial incentive to change energy use.*" [1]

If passed by ballot, accomplished by a strong focus on the marketing and wording of such a proposal, a "clean energy and pollution reduction" tariff could provide the City of Tucson with the necessary funds to finance the important and meaningful GHG emission reduction projects outlined in this report.

However, directly changing energy use might not be accomplished through a Tucson-only tax over the time periods contemplated in this report. It is outside the scope of this report to debate price versus quantity (ie, tax v. caps) policy mechanisms. Nevertheless, it is the position of Westmoreland Associates that carbon tax implementation in and of itself will not lead to GHG emission reductions in the short-term. This is partially due to the inelastic qualities of energy demand over in the short-term and, at the rates considered in other cities, the impact is assumed to be too small for the vast majority of consumers to make behavior modifications.[2]

Business as Usual:

Currently, the Arizona Corporation Commission (ACC) has approved a "Renewable Energy Standard Tariff" (REST) that allows utilities to charge a tariff on energy consumption such that the utilities can use that revenue to help meet their mandated renewable energy goals (ACC mandates that renewable energy sources account for 15% of a utility's power generation by 2025).[3]

REST rates were lowered in November 2010 to $0.0071/kWh in 2011. The cap that any residential customer can pay was raised to $4.50 with Tucson Electric Power (TEP) estimating that "typical" residential customers will pay $3.59 per month.[4] Through all sources (residential, small business, large commercial, and industrial), TEP estimates their 2011 revenue at $35.6 million.[5]

The City also taxes utility bills to generate revenue. On July 1, 2009, City Council approved a doubling of the utility tax raising it from 2% to 4%.[6] This increase is anticipated to generate $14.3 million per year, but the funds are not earmarked for clean energy or emission reduction projects.[7]

The City of Tucson's climate goals could greatly benefit from introducing and supporting the passing of legislation or increases to the utility tax that generates revenue, similar to that described above, for use in implementing GHG mitigation measures such as those in this report.

Description of Measure and Implementation Scenario:

This measure is to introduce by ballot a clean energy and pollution reduction tariff and or raise the utility tax to fund other GHG mitigation measures. Relative to the new tariff, and using just TEP's 2009 Utility Operating Statistics, the breakdown of kWh per retail customers were as follows: [8]

Residential:	3,905,696,000
Commercial:	1,988,356,000
Industrial:	2,160,946,000
Mining:	1,064,830,000
Public Authorities:	250,915,000.

For illustrative purposes, this analysis assumes Boulder's "carbon tax" (also known as their "Climate Action Plan tax") rates of: [9]

Residential:	$0.0049 / kWh
Commercial:	$0.0009 / kWh
Industrial:	$0.0003 / kWh.

Another revenue generation pathway is to increase the City utility tax rate above the current 4% or to allocate some funding already generated to clean energy and other mitigation projects.

Has the Measure been implemented elsewhere and with what results?:

As indicated, Boulder successfully passed by ballot a Climate Action Plan tax with the above indicated rates. The local utility (Xcel) collects the tax for City though their monthly utility billing. Electricity derived from renewables is except from the tax. The tax is projected to generate $1.6 million of revenue in 2010.

Also, the City utility tax is amendable via City Council vote as illustrated by the July 1, 2009 increase.

Energy/Emission analysis:

See measures funded.

Economic analysis:

It is outside the scope of this report to determine rates that would be acceptable to Tucson's constituents, or if such a tariff would be acceptable at all. However, using TEP's 2009 distributed retail kWh and Boulder's rates, the following would be Tucson's revenue generation:

Residential:	3,905,696,000 kWh x $0.0049/kWh = $ 19.138 million
Commercial:	1,988,356,000 kWh x $0.0009/kWh = $ 1.790 million
Industrial:	2,160,946,000 kWh x $0.0003/kWh = $ 0.648 million
Mining:	1,064,830,000 kWh x $0.0003/kWh = $ 0.319 million
	TOTAL = $21.895 million

Increasing the utility tax is projected to raise approximately ***$7.15 million*** per each 1% increase.[7]

Co-benefits:

Revenue generated from such an activity can also be used to fund adaptation measures along with mitigation measures. There may also be some behavior change stimulated by the increase in energy costs.

Equitability:

The surcharge can be structured accordingly.

Potential unintended consequences:

Due to the economic downturn over the last two years and voters swing away from public spending as indicated during the 2010 General Election, trying to implement this measure may be a political liability. Mayor and City Council will have to weigh the pros and cons of pursuing such an endeavor.

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

[1] From Carbon Tax tab of ICLEI CAPPA spreadsheet model downloadable from: http://www.icleiusa.org/action-center/tools/cappa-decision-support-tool/

[2] World development report 2010: development and climate change, pg. 213

[3] http://www.tep.com/company/news/REST.asp

[4] Ibid.

[5] Ibid.

[6] City of Tucson Notice to Taxpayers found at: http://cms3.tucsonaz.gov/files/finance/NoticetoTaxpayersJuneReturns.pdf

[7] http://www.azbiz.com/articles/2009/05/29/news/doc4a2021211b61a001024704.txt

[8] From TEP's 2010 SEC filing found at: http://www.faqs.org/sec-filings/100226/TUCSON-ELECTRIC-POWER-CO_10-K/

[9] http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=7698&Itemid=2844

Measure: Mandatory Use of Green Concrete (G1)

Westmoreland Associates has determined that implementing this measure would result in emission reductions that are outside the boundary of the City's GHG Inventory. However, implementation would result in regional emissions and pollution reductions and, therefore, is worth considering.

Mandate use of "green" concrete, defined as 20% fly ash and 10% recycled aggregate, in all new commercial construction.

COT ARRA RFP Summary:

Emission reduction potential:	17,473 tCO2e over 10-years (outside of COT boundary)
Percentage of goal (2012):	NA
Percentage of goal (2020):	NA
Total annual average implementation costs:	Cost savings of $1/short-ton resulting in approximately $92K of savings
Entity that bears the costs of implementation:	Developer
Savings per tCO_2e:	$53 / tCO_2e
Net annual savings:	Cost savings of $1/short-ton
Entity that realizes the financial return:	Developer
Equitability (progressive/regressive, income/revenue neutral, etc):	Neutral
Potential unintended consequences:	Perverse incentive to increase production of fly ash, although this threat is minimal

Background information:

Concrete is a matrix of cement, course and fine aggregates, water, and air.[1] Cement production is the third largest emitter of CO_2 in the US behind fossil fuels and iron/steel production.[2] Emissions from the manufacturing of cement are "*emitted from the calcination process of limestone, from combustion of fuels in the kiln, as well as from power generation*".[3] Total emissions are nearly split 50/50 between processing and energy use. Moreover, GHG emissions also exist from the production and use of aggregate in concrete production.

Many options exist for regulating authorities to reduce emissions from concrete production. Among these options, some easily obtainable reductions can be realized from using an increased percentage of fly ash, a byproduct of coal combustion, and recycled aggregate. In many cases, these changes lead to a net cost reduction.[4]

According to Denver's Climate Action Plan (2007), "*a 20 percent mix with concrete, the use of fly ash (a by-product from coal-fired power plants) will save up to 25 percent of the carbon emissions associated with concrete, while making a highly durable, less expensive, and eco-efficient product*." Further emission reductions, on the order of 0.01 tCO_2e per short ton of concrete produced, can be realized by using recycled aggregate.[5] These measures, especially when combined, can help the City of Tucson (COT) reduce regional emissions at a net savings to the development projects.

Business as Usual:

Under a business-as-usual scenario, new commercial construction will continue to use concrete mix designs that don't utilize fly ash percentages that are deemed structurally acceptable in Denver, while accounting for project specific load designs.[6]

Description of Measure and Implementation Scenario:

This analysis assumes the COT legislates mandatory minimum use of 20% fly ash and 10% recycled aggregate in all commercial concrete design mixes. This quantification uses an annual consumption of cement totaling 8,400 metric tons for the COT concrete consumption.[7] Current mix designs call for under 3% fly ash and 0% recycled aggregate.[8] Mixes of these percentages are considered the "baseline" from which potential reductions will be quantified. Assuming that concrete is 10% cement by weight, 8,400 metric tons of cement would mean annual commercial short ton consumption of concrete in the COT would be 92,594.

Has the Measure been implemented elsewhere and with what results?:

Denver has mandated the use of “green concrete”. According to their Climate Action Plan the policy covers “*concrete used in public and private projects: roads, shopping malls, homes, etc.*” Resulting emission reductions from this policy are yet to be published as the mandate is in its infancy, however Denver anticipates approximately 100,000 tCO_2e per year reduction at an immediate cost savings of $1/ton of concrete.

Energy/Emission analysis:

Description	***Input***	***Notes***
Emissions per short ton of concrete produced (w/ no fly ash)	0.111	tCO_2e/short-ton; See below for calculations
Baseline fly ash percentage	3%	
Baseline recycled aggregate percentage	0%	
Emission reduction percentage via using 20% fly ash vs. 0%	11.2%	Derived from Flower and Sanjayan[9]; See below for calculations
Emission reduction percentage via using 100% recycled aggregate (additional to fly ash)	9%	Derived from EPA modeling[10]
Projected emission reductions above baseline scenarios via using 20% fly ash and 10% recycled aggregate	17.2%	Calculated from above numbers
Projected short tons of annual commercial concrete consumption in COT	92,594	
Total potential annual emission reductions	1,747	tCO_2e per year

Contribution analysis:		
COT 1990 Citywide GHG emissions (baseline):[11]	5,461,020	tCO_2e
MCPA 7% reduction target for COT:	5,078,749	
2012 BAU GHG emissions projection:	7,000,000	

2020 BAU GHG emissions projection:	7,343,141	
GHG emissions reduction to meet 7% goal (2012):	1,921,251	
GHG emissions reduction to meet 7% goal (2020):	2,264,392	
Mandatory use of green concrete in commercial construction		
Contribution of G1 Green Concrete (over 10-yrs):	17,473	tCO_2e
% Contribution of G1 Green Concrete (over 10-yrs):	NA	

Economic analysis:

The Denver Climate Action Plan calls for, approximately, a savings of $1 per short ton of concrete for use of these measures. Cost savings are estimated to be $1/(0.111 * 17.2%) (derived from above). This equals a ***savings of \$53/tCO₂e*** with an overall annual savings of approximately $92,000.

Co-benefits:

Diversion of waste from landfills is the most noticeable attribute of both fly ash and recycled aggregate. Also, given the structural properties of fly ash, its use in concrete mixtures makes the product easier to work with.[12]

Equitability:

Neutral.

Potential unintended consequences:

A possible negative unintended consequence of mandating the use of any specific material is that the resulting demand may drive up the costs. Per Denver's CAP: "*Using fly ash to substitute for a portion of cement in concrete is currently economically beneficial, as fly ash typically costs less or the same as cement. Future supplies and costs of fly ash are likely to change as more cities institute fly ash concrete policies, with the potential to drive up demand*." Also, the toxicity levels of fly ash, and the products that contain it, are currently of serious concern.[13] Lastly, it is argued that aiming to increase the use of coal combustion waste products creates a perverse incentive to continue the use of coal.[14]

Calculations:

Calculation of emissions per short ton of concrete produced (based on Flower and Sanjayan[9]):

- $(0.29\ tCO_2e/m^3) \times (2371\ kg\ of\ concrete\ /\ m^3)^{-1\ (Note\ 15)} \times (907.2\ kg\ /\ short\ ton)$

Derivation of 11.2% reduction from 20% fly ash (assumes linear interpolation of Flower and Sanjayan[9]):

- (25% fly ash /14% reduction (AVG)) = (20% fly ash / ***X*** %); where ***X*** = 11.2%

General Note: All references retrieved October through December of 2010 unless otherwise noted.

Endnotes:

1 http://www.epa.gov/osw/conserve/tools/cpg/pdf/rtc/app-a.pdf

2 http://www.epa.gov/climatechange/emissions/co2_human.html

3 Worrell, E., L. Price, N. Martin, C. Hendriks, and L.O. Meida, (2001). Carbon Dioxide Emissions from the Global Cement Industry. Annual Review of Energy and the Environment 26: 303-329.

4 http://www.toolbase.org/Construction-Methods/Concrete-Construction/concrete-aggregate-substitutes#benefits

5 http://epa.gov/climatechange/wycd/waste/downloads/concrete-chapter10-28-10.pdf

6 Denver Climate Action Plan available at: http://www.greenprintdenver.org/docs/DenverClimateActionPlan.pdf

7 This analysis assumes that annual commercial cement consumption over the coming decade is equal to 30% of the 2006 consumption, which can be found at: http://www.cement.org/.

8 Per email communication with Greg Martin, Project Manager for general contractor The Weitz Company (TWC). TWC self-performs concrete work and has working knowledge of current mix designs.

[9] Flower DJM, Sanjayan JG (2007): Green House Gas Emissions due to Concrete Manufacture. Int J LCA 12 (5) 282–288

[10] http://epa.gov/climatechange/wycd/waste/downloads/concrete-chapter10-28-10.pdf

[11] PAG Regional Greenhouse Gas Inventory- 2010

[12] http://www.flyash.com/flyashenvironment.asp

[13] http://www.psr.org/resources/coal-ash-the-toxic-threat-to-our-health-and-environment.html

[14] http://www.peer.org/docs/epa/8_2_10_PEER_comments_GHG_procurement.pdf

[15] http://www.simetric.co.uk/si_materials.htm

Climate Change Measures Not Analyzed

Westmoreland's analysis included several proposed policy measures that, upon review, we determined should not be analyzed in detail at this time. Reasons for this included:

1) The high potential for double counting their benefits with those of other, similar measures;

2) The negligible contribution of some measures to City greenhouse gas reduction goals; and

3) Some measures are already being implemented, which suggests to us that they should simply be promoted and tracked by the City until more information on their actual benefits becomes available.

These measures are presented below with our conclusions regarding their exclusion from detailed analysis at this time, organized by the primary reason for their exclusion,

Potential for Double Counting of Benefits

Extend Employee Subsidy to Bicyclists (T8)

This measure is one of various approaches that can be used to increase bicycle ridership in the City. However, in that a broader bicycling measure has already been analyzed in this report [Double Bicycle Usage – T21] there appears to us to be a large potential for double counting of costs, benefits and GHG reductions to occur.

In addition, we see only a small amount of greenhouse gas savings accruing from a bicycle subsidy program above and beyond that being achieved through other bicycle promotion efforts. For these reasons, we did not analyze this measure.

Negligible Greenhouse Gas Reduction Potential

Young Adult Bus Marketing Campaign (T4)

This measure calls for SunTran to develop a marketing program aimed at getting more young adults to ride the bus via mechanisms such as reduced fares, extended hours and routes, and better advertising.

We did not analyze this measure given that the current budget challenges of the City seem to preclude any extensions in SunTran service or fare reductions for the near term. In fact, the opposite – further fare increases and reduced levels of service – is being actively discussed. Should the general Tucson economy reach a point that City budgets allow for increased costs and lower revenues from a young adult bus marketing plan, this measure can be revisited.

Measures Already Being Implemented

Incentivized Recycling Program (G12)

Since this proposed measure was identified for analysis in 2010, the City's Environmental Services Division has instituted a volume-based, incentivized, residential waste and recycling program known as "Right Size Your Can." The goal is to incentivize households, via waste-collection rates, to recycle more and send less waste to the landfill.

Under this program customers have the option of choosing among three different sized garbage containers (48, 65, and 95 gallons). The smaller the garbage container volume the lower will be the household's monthly curbside garbage collection fee.

This program is in its infancy and it is too soon to determine if the current structure is adequate to incentivize recycling as intended.

We recommend the City continue to promote this program as well as collect detailed data on numbers and levels of participation that can later be correlated to changes in recycling or landfilled volumes as more households participate. The City should return to this measure after a full year of program implementation and data collection to see if additional incentives would be useful in spurring additional residential recycling.

Safe Walk to School Program (T9)

The City currently has a pilot "Safe Walk to School" program that should be promoted and expanded via a more aggressive marketing campaign. Lessons learned from the pilot should be used to inform the design of a broader program along with the development of metrics to evaluate true energy, cost and emissions reduction occurring.

Upon first review of the draft measure provided, we believe the potential greenhouse gas savings from an expanded Safe Walk to School program to be negligible, even in a post-pilot scenario.

We recommend the City continue to explore an expanded Safe Walk to School program that might be put in place as fuel prices continue to rise and lessons from the pilot program are more completely examined.

Incentivized Alternative Transportation (T11)

The Pima Association of Governments (PAG) has historically administered and promoted a Travel Reduction Program aimed at encouraging the use of alternatives to automobiles.

According to the PAG 2009-2010 Annual Report,

> "In FY 2009-10, Pima County experienced a sharp economic downturn, which impacted all the Travel Reduction Program (TRP) participating employers, as well as PAG. In

June 2009, the uncertainty of the Arizona Department of Environmental Quality (ADEQ) funding for the Travel Reduction Program resulted in staff reductions. The remaining staff focused on supporting the current businesses in the TRP and assisting commuters, rather than on business development activities."

"Some TRP outreach activities were delegated to PAG's communications department, and a consultant was used on a temporary basis to work on business development and locate companies that were not participating in the TRP as required by the local ordinances."

As PAG reported, "Quite a few companies were recruited, but many others dropped out due to downsizing and layoffs."

The Report went on to note that PAG's Key focus areas at the moment include branding, developing consistent messages and materials, using new outreach tools such as social media and targeted marketing.

PAG further reported that the response generated by these focused efforts has been quite positive as demonstrated by indicators such as increased Web visits, higher numbers of registered alternate mode users and creation of more vanpools.

However, until funding levels return to pre-economic downturn levels, even the progress seen under the former alternative transportation program effort cannot be assured. Therefore, we recommend that the City continue to support PAG's efforts and encourage resumption of ADEQ funding for them.

As fuel costs rise in the decade ahead, we project renewed interest in the PAG alternative transportation initiatives which may then resume achieving VMT, cost, and emissions reductions as intended. Only at that time can the City expect success in promoting an expansion of such initiatives with their associated contribution to the City's GHG reduction goals.

Electric Vehicle Charging Stations (T17)

At the time this measure was initially developed for analysis, electric vehicle (EV) technology was less commercially developed than it is at present. Local government incentives and actions were once thought necessary to spur deployment of EV charging stations and associated infrastructure. In the last 12-18 months however, the private sector has demonstrated its willingness to deploy city-wide EV charging station networks in different parts of the U.S. without government assistance.

This, together with the expected rapid commercialization of electric vehicles by several manufacturers in 2011-2012, persuades us that the private sector has taken ownership of EV vehicle and charging station deployment and no further action is needed by City government at this time regarding charging infrastructure, aside from its own fleet. However, we recommend that City incentives be considered to boost electric vehicle ownership in the City (see Purchasing Incentives for Zero Emission Vehicles and Plug-in Hybrid Vehicles).

The City should, however, continue to look for opportunities to remove any barriers (none identified at present) to the installation of EV charging stations or use of EVs themselves. The City may also, once budget circumstances allow, consider purchasing EVs for City fleet use though we are not recommending that at this time because they are not yet cost-effective.

Number	Sector	Measure Title	CO2e savings (metric tons)	% of overall GHG reduction goal	Cost/ Metric GHG reduced	Full Implementation	Consistency with Adaption Strategy	Co-Benefits (economic, social, etc.)	Community Support	Comments from UA	Notes for Consultant
G9	Mixed Residential/ Commercial	**Mandatory Salvaging/Recycling of Construction and Demo materials**								According to City staff, 50-80% of construction waste is recycled and a 50% requirement would be ok, anything higher might be problematic. Construction is more feasible than demo. http://www.sandiego.gov/environmental-services/recycling/cdrecycling.shtml	**Consultant will need to complete analysis.** City projects already recycling 50-80%. Mandatory community policy may be met with some resistance.
G4b	Commercial	**Mandatory Commercial Recycling- 50% waste offset**								UA did not complete analysis. http://www.sandiego.gov/environmental-services/recycling/ro/pdf/071128containerguide.pdf	**Consultant will need to complete analysis.** City recycles 40,000 residential and 4,000 commercial tons a year. Collects 150,000 residential and 95,000 commercial tons garbage each year. Includes B&B WM has transfer station but waste goes to Phx
G2	Commercial construction	**Research solar incentives/accelerators, such as PACE, etc.**	102,000	3.6 to 4%						Energy savings from covering 10% of available business rooftops with solar panels (very rough estimate of square footage available here). Original UA analysis on Energy Efficiency Building Showcase replaced with additional research on solar accelerators.	**Consultant will provide insight and recommend strategies for increasing solar.** Split into PV and solar thermal requirements for commercial+residential. Incentives for getting solar on buildings. What are the returns if 10% participation for each category
G2a		**Commercial PV**								No report	Get cost/benefit from Bruce of City solar with bonds
G2c		**Commercial Thermal**								No report	
G2d		**Residential Thermal**	370	0.01%		372 homes each year, 3,720 after 10 years=3,700 ghg reduction or .14% of goal				No report	
G2e		**Residential PV**								No report	Based on TEP Q1 2010 numbers. At current rates, will take 74 years to reach 5% goal. There are 23 commercial pv units reserved. Need 588,571 kW of pv installed to reach 20% goal.
G10b	Residential/Commercial	**Mandatory Solar Hot Water Heating for New Pools**	177-4118	07-.015%	$534/ton GHG on 1000 sq ft, 82 degrees uncovered	1770-41180 over 10 years, max 1.5% of goal		Could deter development of new pools, promote community pools, save potable water		UPDATE: emailed city dev - number of permits issued - reply Residential Pools: 1321 Commercial Pools: 21 (1/1/05 through 12/31/09) , solar store - 520-322-5180, calculated cost for 450 sq ft and 3000 sq ft pools, flat roof, solar coils (13 and 84 coils), $4,300 and $25,000 estimate. Heat effciently except for Dec/Jan	**Consultant to review and revise.** Only 10% of pools in Tucson have heating? per Clayton Trevillyan (DSD)
G6a	Commercial/ Code and Policy Changes	**Implementation of Smart Meters in commercial buildings**	28,487	1.06%						**Low cost, high payback.** All new buildings required to have smart meters and assumed 10% of existing buildings will get them voluntarily by end of 2nd year. Calcs are sound for energy reduction associated with having smart meters. CO2 reduction is just from change in 10% of existing businesses. Cost of installing smart meters in existing businesses is absorbed by business and is offset by their energy savings costs.	**Consultant to refine evaluation.**
G8	Commercial	**Mandatory Cool Roof/Energy Star**	9,937	0.37%	approx. $1/sq. ft. or $2.8 million=$282 /ghg	99,370, 3.7% after 10 years	Yes	Mitigates UHI		First year savings of program to put cool roofs on half of new homes / commercial businesses (1000 homes; 25 commercial businesses); assumes cool roof alone can save 50% of all building energy costs. Cost based on 2001 prices.	**Consultant expand to Energy Star.** Some HOAs don't allow white roofs.
G17	Residential Construction	**Residential retrofits- Point of Sale ordinance (Berkley)**	4,444	0.02% in first year		9594 homes per year. 95,940 homes afer 10 years=44,440 or 1.7% of goal				First year savings assuming 100% participation in point of purchase retrofits: 14,760 homes sold/yr * 65% older than 25 yrs * 4% energy reduction * (14.8 Mbtu/yr + 12.4 MWhr/yr baseline)	**Consultant to expand to Berkely point-of-sale ordinance (RECO).** Berkely does not have data on household energy savings. There are no additional costs to enforce ordinance as they were absorbed by existing staff.
G22	Residential/Commercial Construction	**Expand Existing Green Building Program- remodel and new build**								No Report	**Consultant to evaluate mandatory green building program for new builds and remodels.** expand existing res prgrm to commercial, adopt county renovation program, what components get biggest ghg return and make mandatory, make Clayton an ombusdman, how to incentivize?
G1	Commercial construction	**Mandatory Use of Green Concrete- 20% fly ash and 10% recycled aggregate**	42,512	1.60%	savings of $3.14 per ton	425120=16% of goal				Based on Denver saving of 25% of concrete emissions, but very rough stats for Tucson (based on state averages, not Tucson-specific); ranked high for high potential, but we should double-check student methods	**Consultant will recalculate.** from Rich Michal- 1/2 of concrete produced now uses 15 to 20% fly ash (mostly residental), commerical has more opportunity, working to see if worth recalculating--get total volume of concrete
G23	Residential/Commercial	**Separate Metering for Pools w/ Higher Rate**						Could deter development of new pools, promote community pools, save potable water		No report	**Consultant to complete and expand to different rates for different water uses instead of just pool users.**

Number	Sector	Measure Title	CO2e savings (metric tons)	% of overall GHG reduction goal	Cost/ Metric GHG reduced	Full Implementation	Consistency with Adaption Strategy	Co-Benefits (economic, social, etc.)	Community Support	Comments from UA	Notes for Consultant
E1/E19a	Transportation	**Use of Warm-mix asphalt in road resurfacing**	5,550	0.0091%						Seems like another "low hanging fruit". Still unknown - is WMA more expensive? Harder to access? Certainly $$ is saved in energy costs.	**Consultant to combine and evaluate.** E1 and E1 9 same with different scale. Ask Phil costs of warm mix asphalt. Is it already being used? Calculations are wrong per alyson.
E2	Commercial/ Auditing and improvements	**Lessor-Lessee Partnership - EPA Energy Star rating improvement to 75**	35,410	1.3% per year at 5% participation rate		708,200 tons, 26%				Partnerships between leasor and leasee to improve energy efficiency of leased space; note this includes commercial business leasors *not* large apartment facilities, because too many people per overall facility (based on other places' implementation of this). City provides website, e.g. modeled after the "California Sustainability Alliance" website, with include tenant and landlord tools to assist in the process. Leasor and leasee share costs and benefits of improvements, and improvement goal is Energy Star rating of 75. Participation rate assumes 5% of leased space per year would be converted to EnStar of at least 75 through these partnerships. In my opinion participation rate might be too high - perhaps 1% per year for first several years would be more likely... Note, this and the "green landlord" measure are closely related but not identical - the partnerships are a mechanism for *converting* space to higher-efficiency, while the database is a mechanism for inventorying and promoting that space.	**Consultant to evaluate as comprehensive program with E3, E16, E17. Low cost, high payback.**
E3	Commercial/ Auditing and improvements	**Green Landlord Measure- website combined with Lessor-Lessee Partnership**	45,528	1.70%	0.11	910,560 with 100% participation				**Med-to-low cost, high payback.** A database of green commercial and large-residential (apartment compelxes) landlords - participants would be required to score an Energy Star rating of 75 or greater on their facility. Landlords would shoulder burden of proof but City would have to validate, and examples of how to do this *are* described. 5% participation is assumed in year 1, with an additional 5% per year thereafter (plateauing at some undetermined future time), such that 5% of the sqaure footage per year is converted over. The landlords also save signficant money because of their efficiency improvements. In my opinion participation rate *might* be too high - perhaps 1% per year for first several years would be more likely...	re-calculate for apartment complexes to reduce duplication with E2, even though commercial space could participate. Database complements E2. Require energy use disclosure of homes for sale.
E16	Residential - behavior, renting	**Rental Unit Energy Consumption Disclosure**	41	0.0015%						This CO2 savings is a per unit number. The strategy is okay, but Chris had a hard time quanitifying participation and actual behavioral change.	
E12	Municipal	**Energy Performance Contracting**	8451	0.30%		TCC + 15 community centers				This is assuming energy perfomance contracting at 15 community centers and the TCC. Annika did a ton of research on this, and the assumptions seem good. TCC is already undertaking this, so seems like something real for the city	**Contractor to evaluate.**
E13	Residential - behavior, renting	**Energy Efficient Household Appliance Incentive-HVAC**	91,407	3.40%		83,843 air conditioners per year				Overall, a good strategy - but I think the patricipation rate used is much too high, as would be cost	**Contractor to evaluate.** recalc with 10% homes aware and 25% of them make change. Look at state rebate numbers. Find out kWh savings and cost savings from TEP of upgrading air conditioning. What other cities are doing ee loans
E14	Residential - behavior, renting	**Community Climate Challenge Program**	128,867	4.8% over 5 years						This is a hard strategy to quantify, pretty much having people/businesses "pledge" to reduce emissions by 5% per year. Research and write-up are really good, the measure would be hard to implement with high participation	**Contractor to expand to include water and evaluate.** Issue with degree in confidence in participation rate
E15	Residential - behavior, renting	**Electricity Carbon Surcharge**	625,861	23.30%						Once again, another hard strategy to quantify. It's a carbon tax. The assumptions are based on Boulder. I think Tucson's political climate would make it hard to pass, but if it did - would have great results.	**Contractor to revisit. Ideas include: surcharge, utility tax, carbon tax on individual items.** difficult to implement. When were TEP's fees implemented? Equity issues--sliding scale? Can we have a city sales tax on the utilities? Progressive, instead of sales tax increase. Make politically feasible by substituting a sales tax?
E22	Municipal	**Solar Street Lights**								No report	**Consultant to complete. City may be able to calc with cost estimates.** Joanie Sawyer
E23	All	**Energy Efficiency Education Program(s)**								No report	**Consultant to complete.**

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T1	Commercial construction	**Reduce parking space requirements**	1,171	0.04%					Potential issues with neighborhoods	Existing requirement is 1 tree per 4 parking spaces. assumes 2% of mall shopping trips are replaced by bike/bus, but includes no consideration of the potentially bigger savings of encouraging alternative to work commutes	**Consultant to evaluate.** issues with existing parking code-requires minimum instead of maximum number of spots. What were the recent changes to City parking reqs? Adam Smith
T6	Transportation	**Smart Growth/ Transit-Oriented Development/Infill**	29,600	1.10%						Difficult to quantify change in pop density and miles traveled; assumptions based on comparisons of different cities may not hold up for changes in one place?	**Consultant to evaluate and recommend programs that are effective.**
T20	Transportation	**Anti-idling ordinance**								No report	**Consultant to evaluate.**
T10	Transportation	**Vehicle Maintenance and behavior education program**	25,660	3.80%						Student estimate was based on the effect of having all 4 tires underinflated, but underinflation stats are for "at least one tire" - hard to convert these numbers to a meaningful estimate of the gallons curerntly wasted by underinflation. I took her number (102,641) and divided by 4. It looks like low-hanging fruit, at low cost.	**Consultant to evaluate as vehicle maintenance and driving behavior education program.** Can PAG institute with employers as part of travel reduction program? Give out tire gauges? PAG- low return
T21	Transportation	**Double bike lane usage through improved safety**								No report	**Consultant to evaluate and recommend programs that are effective.** PAG suggests focus on safety of existing infrastructure
T18	Transportation	**CarShare Program**								No report	**Consultant to evaluate.**
T19	Transportation	**Bike Share Program**								No report	**Consultant to evaluate.** Model off UA?
T5	Transportation	**Voluntary Travel Carbon Offset Program**	########	40%						Implementation strategy assumes high participation rates; final # is 20% of Tucsons carbon footprint - can't be right. Offsetting has to be carefully done to avoid additionality and other problems. Cost of $25/ton seems high (if large C savings are realized.)	**Consultant to evaluate.** is air travel part of the ghg inventory?--not accurately. Capture local trust ghg reductions instread? Put offset kiosks in airports?
T7	Transportation	**Increase City Sales Tax for High Emission Vehicles**	460	0.0069% 0.0275%	$760.46 (USD/metric ton)					Range represents increased hybrid purchases from 25-100%. Used too high a value for sales tax (confused sales and income tax credits). Overestimate by factor of 2. This could influence participation rate. Otherwise #s are good.	**Consultant to evaluate as increase in sales tax for high emission vehicles, revenues used to fund mitigation projects.** Look at socioeconomic impacts. State registration incentive is $28/yr

Number	Sector	Measure Title	CO2e savings (metric tons)	% of overall GHG reduction goal	Cost/ Metric GHG reduced	Full Implementation	Consistency with Adaption Strategy	Co-Benefits (economic, social, etc.)	Community Support	Comments from UA	Notes for Consultant
G4	Commercial/ Auditing and improvements	**Increased Commercial Recycling**	15573 per year	.58% per year						**Low-to-med cost, high payback.** Goal to halve the amount of recyclable materials currently going into Landfill, from *all* businesses in Tucson. Tucson Env. Services would send out educational pamphlets -recycling will save the businesses money in disposal costs. The Better Business Bureau would recognize businesses that meet this target. City *could* spend money on ad campaign promoting program and recognizing top achievers. So, *assuming* T.E.S. is willing to send out fliers, cost to city is zero to low.	
G4a	Commercial	**Increased Commercial Recycling-EECBG Program**	156 businesses at 3031 per year	.11% per year/.4% after 3 years	$150,000 for 3 years= $14.84	10,105 per year after 3 years					**City already implementing.** based on 1000 sq ft pool w no cover
G12	Residential - behavior, renting	**Incentivized Recycling Program- Volume Based**	41,299	1.50%						**City already implementing.** Simple program with huge potential and fairly easy implementation (similar programs have been implemented around the country with good results). James did a great job with good research and assumptions. In a nutshell decreases waste by 17% and increases recylcing by 3%.	
G2b		**Residential PV (CAPPA using TEP numbers)**	1,815, .91 p	0.00%		2,000 KwH/yr=18,150 after 10 years or .7% of goal				**Consultant will complete. Accelerators to research include PACE (Berkeley).**	
G10a	Municipal	**Solar Hot Water Heat Pools**	142	0.005%	$4,753.50	9 pools				Pretty straightforwad and easy to implement measure (and makes sense in Tucson), values used are good quality and simple. Some initial expense.	
G6b	Residential	**Residential Smart Meter Pilot Program- 100 homes**	43	0.002%	$31 per ton (cumulative) over 15 year life of meter	95,727 metric tons for 255,000 homes (3.5%)				Used conservative estimate of 4% energy savings. Studies show 7-12% savings.	**Not sure if additional analysis needed?**
G3/E21	Commercial/ Auditing and improvements	**LED Lighting Measure**	312	0.006%	$2002.12 w/ 17 year payback	**Get total number of streetlights**				**Ex1. Very "low hanging fruit".** Cost and energy effective replacement of light bulbs. Tons of research in this one, very good assumptions, and some great cost data about how much could be saved after initial implementation cost. **Ex2. Low cost, low payback.** Targets 4 intersections in city for replacement of yellow incandescent signal light with yellow LED light; these are intersections that already have red and green LEDs. Potential for cost to be absorbed by TEP since it makes these intersections more efficient and they have lots of green incentives already in place.	
G3/E21b	Municipal	**EECBG- Neigh Streetlight LED Replacement**	295	0.0001%	$1433.89 w/ 10 year payback	9,000 streetlights= .07%				**City already implementing.**	
G14a	Residential Construction	**Home weatherization**	105	0.004%		20,000 homes (10%)					
		CAPPA weatherization calculations	21,349	0.80%	$2,729	20,000 homes				**City already implementing.** Estimated cost is $58 million.	
G14b	Residential	**EECBG weatherization- 350 homes**	722	0.02%	$1524 based on total programmatic costs	350 homes				CAPPA estimates about half (374) the GHG reductions.	
E7	Commercial/ Behavior and education	**Climate Wise**	29,518	1.10%		295,180				**Med. cost, high payback.** Voluntary program of city businesses, giving public recognition of achievements for those involved. Fairly conservative participation rate for Year 1 and likely significant scaling up thereafter - thus these CO2 savings represent low end at start of program. Climate Wise includes reductions in energy, and waste - student calc'd water but that didn't get assessed by Sue. Calcs include a reasonable participation rate and an OK scaling from Ft. Collins (which has a robust "Climate Wise" program), just not an optimal application of those #s to Tucson I think. So, my fiath in these exact #s isn't all that great, and I think they're too high. However, the fact that Ft. Collins does have such a strong and successful program in place provides a great model for Tucson, which helps politically and practically. The reason this is medium cost rather than free, despite being voluntary program, is based on Ft. Collins - they have 3.5 full-time employee and an annual budget of $70k - presumably the employees perform education, outreach, advertizing, recognition, etc...	**City already implementing, includes components of E5 and E6.**
		EECBG Green Bus Program	20,000	0.70%	$22.00	75 businesses					**City already implementing, includes components of E5 and E6.**
E19/E1b	Commercial construction	**Warm asphalt mix**	246	0.01%		pilot					
E10	Mixed Residential/ Commercial	**Promotion of Energy Efficiency through New Construction Permitting**	1,466	0.05%		14,660				first year savings assuming 5% of 2393 new homes will participate	
T2	Commercial/ Auditing and improvements	**Telework Pilot Program**	1,040	0.04%						**High cost, low payback.** Targets the 3 largest Tucson employers: UofA, Raytheon, and Davis-Montham, for a 1% dcrease in the # of commuter miles traveled at each business. Mechanism of reduction is a 5% employee partication rate involving telecommuting 1 day/week. Based on incentivized telework programs elsewhere, this measure advocates a tax credit to businesses for establishing and promoting telework programs. Some ideas are mentioned for how to make it revenue neutral (e.g. higher sales tax on gas-guzzling vehicles) but this seems like an unresolved challenge that would have to be worked out to make this measure viable.	**T2, T4, T8, T11 implemented by PAG. Combine into support for travel reduction programs.** how many businesses already participate? How can we increase participation rates? Currently no subsidies, liability issues
T4	Transportation	**Young Adult Bus Marketing Campaign**	5,500	0.20%						Good summary of successful bus marketing in other cities; range of increase in ridership ranged 7-23%; they used 15.5% average. (and excluded the 550% increase from Boulder)	Upass already exists. Can we increase participation rates? Is safety an issue?
T8	Transportation	**Extend Employee Subsidy to Bicyclists**	1,134	0.042%						Assumptions are conservative (good). Natural gas savings cited - not sure of the source of this?	Reduce parking requirements with bike infrastructure, subsidize cost of bicycle
T11	Transportation	**Incentivized Alternative Transportation**	40,220	1.50%						This is the estimat of carbon already saved by measures already in place at relatively small cost. How to increase/expand program?? What would be the impact of more publicity or larger incentives?	work with PAG, package all alt modes measures
T9	Transportation	**Safe Walk To School Routes Program**	1,290							**Consultant to evaluate.** Used same CO2 conversion for both diesel and gas; some assumptions not clear in calcs; participation rate seems very uncertain.	safe routes to school coordinator-matt zoll at County. Existing pilot program-can expand to all schools?
T3	Municipal	**City Fleet Carbon Neutral by 2020**	25,500	0.09%	Austin spent 8 million					Carolyn did a good job with this, and it would have a huge impact on carbon. However, implementation is poor (planting wayyy too many trees) and cost would be astronomical. Not very likely.	**Being evaluated by internal Green Teams**
T13	Transportation	**Roundabouts**	1,078							Student cited different ways to estimate CO2 saved at rundabouts but did not compare them - this should be done. Ancillary benefits include safety.	ADOT requires consideration of roundabouts?
T17	Transportation	**Electric Vehicle Charging Stations**									**City already implementing.** Tucson getting 5 stations. Bookmans spent $70,000 on 3 stations

B. Projected Energy Costs

To estimate the financial impacts of the Committee's proposed climate-mitigation measures, Westmoreland Associates needed to establish a baseline of energy prices from 2011-2040 for vehicle fuels, electricity and natural gas.

We chose to assume energy prices as follows, assuming a price for vehicle fuels to 2030 given the assumption of a 10-year life for vehicles purchased 2011-2020, and assuming a price for electricity and natural gas to 2040 given a 20-year life for efficiency improvements reducing electricity and natural gas in 2020.

Vehicle fuels

As shown by the oil shocks of the 1970s and the generally unpredicted oil price swings in 2008 (reaching $140/bbl before dropping nearly 50%), predicting energy prices is perilous. We examined future projections from the US Energy Information Agency of the Department of Energy (EIA), the International Energy Agency, and predictions adopted by the Electrification Coalition prior to setting the energy price assumptions used in this analysis.

The difficulty of predicting prices is shown by the extremely wide range of the three. The 2010 reference case price prediction of $3.07 has already been dramatically increased in the 2011 EIA predictions to $3.29/gallon average for 2012.[1]

One reasonable certainty is that global energy demand will continue to grow, especially in developing countries, and that vehicle fuel sources will be stressed. The BP energy and carbon emissions outlook to 2030 expected global energy demand to grow 0.7% per person per year, the same rate as 1970-1990. This results in world primary energy consumption growing 39% from 2011-2030. Global liquid fuels demand is projected to increase by 16.5 million barrels per day to 102 million by 2030 from its present level of 85. Global oil consumption is projected to grow 0.9% per year.[2]

Fuel prices in the short-term are often seen as a function of the reserves available in the petroleum production system.

Westmoreland Associates chose to assume the following regarding vehicle fuel prices:

Use the US average gasoline price prediction adopted by the EIA in 2011 for 2011, $3.19/gallon, reduced by 5% to reflect historically low Tucson prices relative to US average prices.

Adopt the predictions of the Electrification Coalition for 2012-2020, adjusted 5% down to reflect historic Tucson prices relative to US averages. This represents a 4.3%/yr increase from 2011 prices to 2020.

Diesel prices are assumed to be 16% greater than Tucson gasoline prices.

After 2020, the prices are assumed to increase 2.4%/yr. reaching $4.94 by 2035.[3]

Table 1: Tucson vehicle fuel price assumptions ("regular" 87 octane gasoline, 100% petroleum-based diesel):

Year	Gasoline	Diesel
2011	$3.01	$3.49
2012	3.18	3.69
2013	3.52	4.09
2014	3.77	4.37
2015	3.96	4.60
2016	4.09	4.75
2017	4.20	4.87
2018	4.28	4.96
2019	4.33	5.03
2020	4.37	5.07
2021	4.42	5.13
2022	4.48	5.20
2023	4.53	5.26
2024	4.59	5.33
2025	4.65	5.39
2026	4.71	5.46
2027	4.76	5.53
2028	4.82	5.59
2029	4.88	5.66
2030	4.94	5.73

Electricity and Natural Gas Prices

Electricity and natural gas prices tend to be more locally variant than vehicle fuels. Natural gas prices have become increasingly variable in synch with global markets, and are adjusted nearly monthly by the Arizona Corporation Commission.

The EIA in 2010 projected only one primary fuel source, coal, to experience price increases from 2008 levels to 2015 – an 8% increase. The range of mine-mouth coal prices in 2015 does not vary as much as for petroleum at ~10%, but nevertheless represents a wide range from which to accurately predict consumer prices. Steam-produced electricity (primarily coal) increased 75% in production costs from 1998-2008. The EIA's "reference case" predicts 9.9 cents/kWh for 2015, but prices of 11.76 cents/kWh for 2012.[4]

Globally, BP reports that energy used to generate electricity is expected to grow 57% from 2011-2030.

Westmoreland Associates used the following factors in its electricity and natural gas price assumptions:

The US EIA predicted in 2010 that US energy prices for consumers would grow 2.4% per year from 2008 to 2035.[5]

2011 actual electricity and natural gas prices to consumers are increased by 2.4% annually.

2011 residential electricity prices are 8 cents / kWh; commercial/industrial are 7 cents / kWh.

2010 natural gas prices from Southwest Gas averaged 1.24/therm for Tucson residential customers and 1.03/therm for commercial.

Table 2 Electricity and Natural Gas Price Assumptions

Year	Electricity Cents / kWh Residential	Commercial	Natural Gas Therm Residential	Commercial
2011	8.0	7.0	$1.27	$1.05
2012	8.2	7.2	1.30	1.08
2013	8.4	7.3	1.33	1.11
2014	8.6	7.5	1.36	1.13
2015	8.8	7.7	1.40	1.16
2016	9.0	7.9	1.43	1.19
2017	9.2	8.1	1.46	1.22
2018	9.4	8.3	1.50	1.25
2019	9.7	8.5	1.54	1.28
2020	9.9	8.7	1.57	1.31
2021	10.1	8.9	1.61	1.34
2022	10.4	9.1	1.65	1.37
2023	10.6	9.3	1.69	1.40
2024	10.9	9.5	1.73	1.44
2025	11.2	9.8	1.77	1.47
2026	11.4	10.0	1.81	1.51
2027	11.7	10.2	1.86	1.54
2028	12.0	10.5	1.90	1.58
2029	12.3	10.7	1.95	1.62
2030	12.6	11.0	1.99	1.66
2031	12.9	11.2	2.04	1.69
2032	13.2	11.5	2.09	1.74
2033	13.5	11.8	2.14	1.78
2034	13.8	12.1	2.19	1.82
2035	14.1	12.4	2.24	1.85
2036	14.5	12.7	2.30	1.91
2037	14.8	13.0	2.35	1.95
2038	15.2	13.3	2.41	2.00
2039	15.5	13.6	2.47	2.05
2040	15.9	13.9	2.53	2.10

Endnotes:

[1] The 2010 predictions are from US EIA, "2010 Outlook with Predictions to 2035," April 2010. The 2011 predictions are from US EIA, "Short-term Energy Outlook," 11 January 2011, at: http://www.eia.doe.gov/emeu/steo/pub/contents.html.

[2] BP, "BP Energy Outlook 2030," January 2011, at: http://www.bp.com/sectiongenericarticle.do?categoryId=9035979&contentId=7066648.

[3] The assumption of 2.4% annual increase results in a price of $5.26 in 2035, which is less than the US EIA's 2010 Outlook "high oil price" prediction for 2035 less 5% for the Tucson market price adjustment, of $5.36.

[4] The 2010 predictions are from US EIA, "2010 Outlook with Predictions to 2035," April 2010. The 2011 predictions are from US EIA, "Short-term Energy Outlook," 11 January 2011, at: http://www.eia.doe.gov/emeu/steo/pub/contents.html.

[5] US EIA, "Outlook 2010 with Predictions to 2035," p. 52.

C. Energy Conversion Factors

Unit	Equivalent Btu	Equivalent MMBtu	Equivalent kWh
Electricity			
1 GWh	3,412,141,633	3,412	1,000,000
1 MWh	3,412,141	3.412	1,000
1 kWh	3,412	0.003	1
Natural Gas			
1 Therm	100,000	0.100	29.3
Fuel			
1 U.S. gallon (gasoline)	124,000	0.124	-
1 U.S. gallon (diesel)	139,000	0.139	-

D. City of Tucson Greenhouse Gas Emissions Summary

In October 2010, the Pima Association of Governments (PAG) released an update to an earlier 2008 Greenhouse Gas (GHG) Inventory that included GHG emissions for the City of Tucson community and for City of Tucson operations. That 2008 Inventory contained emissions data for calendar 2006, as well as the individual, preceding years of 1990, 2000, and 2005. The inventory included GHG emissions by sector (residential, commercial, industrial, transportation, and waste disposal) for both electricity and natural gas consumption. For these years, PAG reported the following Tucson community-wide emissions as:

Sector	1990 (tons CO_2e)	2000 (tons CO_2e)	2005 (tons CO_2e)	2006 (tons CO_2e)
Residential	1,377,834	1,784,903	1,823,587	1,794,302
Commercial	1,017,395	1,259,554	1,451,555	1.476,431
Industrial	1,146,442	1,877,427	1.428,742	1,376,764
Transportation	1,694,620	2,128,161	2,502,095	2,569,555
Waste	224,689	227,483	237,108	259,163
TOTAL	5,461,020	7,277,528	7,443,087	7,476,215

With the 2010 update, PAG provided data for the same sectors for calendar years 2007 and 2008.

Sector	2007 (tons CO_2e)	2008 (tons CO_2e)
Residential	1,925,759	1,789,726
Commercial	1,545,731	1,454,412
Industrial	1,366,098	1,083,367
Transportation	2,633,651	2,701,124
Waste	242,932	199,045
TOTAL	7,714,171	7,227,674

As explained in **Appendix E**, actual transportation emissions decreased statewide and nationwide from 2006 to 2007 to 2008. Yet the PAG model used to derive the transportation sector values for 2007 and 2008 (above) shows transportation emissions to have increased within the City of Tucson. To correct this error, we derived new values for the 2007 and 2008 transportation sector emissions. When replacing the old PAG numbers with these new, more realistic values, the total emissions number for the City of Tucson reduced to 7 million tons CO_2e in 2008.

As this report was going to print, we learned that PAG has recently recalculated its GHG Inventory for 1990 and now shows City GHG emissions that year some 1.3% lower than previously reported.

E. Transportation Sector Emissions Modification

The 2008 update to the Greenhouse Gas (GHG) Inventory for the City of Tucson was released by the Pima Association of Governments (PAG) in October 2010.[1] As in previous GHG inventories, PAG used its standard transportation planning model to derive a 2008 CO_2e emissions amount for private/commercial vehicle use in the transportation sector in Tucson. The amount generated by the model for private/commercial was 2,688,889 metric tons CO_2e. This value, when compared to 2007 emissions from the same model, indicates a 2.5% increase in private/commercial vehicle use emissions in 2008 over 2007, despite a national recession.

The PAG transportation planning model is described as insensitive to short-term fluctuations in fuel prices and economic cycles, including unemployment numbers for a community.[2]

In 2007, the United States and the City of Tucson were entering a period of recession that continued into late 2009. The U.S. Department of Transportation reports that VMT data declined by 3.7% on urban arterials in Arizona from 2007 to 2008.[3] Further, the same data source indicates that VMT on Arizona roads were essentially flat from 2006 to 2007. The PAG model, meanwhile, derived an emissions value 2.5% higher in 2007 than 2006.

Nationally, The U.S. Environmental Protection Agency reported that greenhouse gas emissions from gasoline-fueled vehicle use declined by 4% from 2007 to 2008.[4]

Thus, actual vehicle miles traveled (VMT) and GHG emissions from gasoline-fueled vehicles data indicate that transportation emissions in 2008 within Tucson should have declined rather than increased.

We do not propose reinventing the entire transportation sector emissions forecasting capability for the City's GHG Inventory. However we propose a modification to the 2007 and 2008 private/commercial vehicle use emissions values derived by a model acknowledged to be insensitive to the economic circumstances of the 2006-2008 time frame.

We have continued to use the model-derived value for CO_2 emissions from the City's transportation sector in 2006, but we have carried it forward unchanged to 2007. Next, we have decreased the model-derived private/commercial vehicle emissions for 2008 from 2,688,889 tons CO_2e to 2,461,328 tons CO_2e. This reduction is consistent with the 3.7% decline in the sector as reported by the US DOT for Arizona between 2007 and 2008. Another source reports that US gasoline consumption declined 4.3% from 2007-2008.[5]

Using these revised and more realistic transportation sector emissions values for the City between 2006-2008, the City's cumulative GHG emissions for 2008 amount to just over 7 million metric tons CO_2e. We use this value in our calculations throughout the report.

Note: U.S. gasoline consumption continued to decline in the years beyond 2008. In 2010, U.S. demand was reported at 344 million gallons/day, 8% less than at the 2006 peak according to government data.[6] Arizona's and Tucson's gasoline consumption can be expected to have behaved the same. Thus, the City's transportation sector GHG emissions from 2008 –2010 should show declines as well.

Endnotes:

[1] Regional Greenhouse Gas Inventory. Pima Association of Governments. October 2010.

[2] Communication with Dr. Aichong Sun, PAG Transportation Modeling Manager. November 17, 2010.

[3] Federal Highway Administration Traffic Volume Trends, USDOT. November 2010.

[4] U.S. Environmental Protection Agency (USEPA). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2008. U.S. EPA #430-R-10-006.2010. http://epa.gov/climatechange/emissions/usinventoryreport.html

[5] US Energy Information Administration. "Esitmated Consumption of Vehicle Fuels in the United States, by Fuel Type." April 2010. http://www.eia.doe.gov/cneaf/alternate/page/atftables/attf_c1.html

[6] "US gas demand should fall for good after '06 peak." Associated Press. December 20, 2010.

F. Forecast of 2020 Business-as-Usual Greenhouse Gas Emissions

Business as Usual Greenhouse Gas Emissions - 2012

Our assignment was to analyze the potential contribution of various greenhouse gas (GHG) mitigation measures for reducing the City's GHG emissions by 2012 to a level 7% below 1990 levels. The most recent GHG inventory conducted by PAG did not include a projection of business-as-usual emissions (growth or decline) for the period from 2008 to 2012, or beyond. Therefore, it was necessary for us to project 2012 GHG emission levels under a business as usual scenario for use in analyzing the contribution of individual mitigation measures

As reported in the most recent GHG Inventory for the City, community greenhouse gas emissions have declined from 2006 to 2008. As noted in **Appendix D**, we believe GHG emissions will be shown to have continued to decline from 2008 levels into 2009 and 2010 owing to the sharp decline in economic activity during and after the most recent recession. We believe that together with the continued decline in residential and commercial construction, the documented decline in transportation emissions, and continued high unemployment into 2011, that actual GHG emissions for the City at the end of 2010 will be shown to be below 7 million tons CO_2e.

As Tucson's economic condition has not yet recovered to its pre-recession level, we are therefore forecasting only a slight rise in overall GHG emissions to 7 million tCO_2e in 2012 from 2010.

We will not know how accurate this forecast is until future GHG inventory updates are performed but we believe it is a defensible projection given current economic data for Tucson and across the region (limited new construction, residential and commercial vacancy rates, reduced vehicle miles traveled, reduced gasoline sales, unemployment rate, possible population loss, etc.)[1]

Business as Usual Greenhouse Gas Emissions – 2020

The Mayors' Climate Protection Agreement (MCPA) goal endorsed by the City of Tucson calls for a reduction in GHG emissions to 7% below 1990 levels by 2012. Most if not all of the measures being evaluated in this report would not see implementation begin until 2012. Therefore, we believe it is not realistic to expect any measurable contribution from them towards the 2012 goal. Our quantification of GHG abatement potential in 2012 [**Figure 1**] illustrates this.

In the absence of any GHG reduction goal for the City beyond 2012, yet wanting to illustrate the mid to long-term potential of the measures evaluated for energy, cost and emissions reductions, we have simply extended the "7% below 1990 levels" goal forward to 2020. However, for this to be useful to our analysis, we also needed to develop a business as usual GHG emissions projection for 2020 against which we might evaluate the reduction potential of the various measures.

Using the national GHG emissions growth forecast to 2020 developed by the U.S. Energy Information Administration (EIA) and modifying them to account for Tucson-specific population growth projections used by PAG, we have arrived at a projected business as usual GHG emissions level for the City of Tucson of 7.34 million metric tons for 2020.

We want to emphasize the importance of the City establishing an updated GHG reduction goal for the community so that climate mitigation planning may proceed in the context of a new, formal emissions reduction target.

The City's updated goal should be framed in light of the growing concerns over the pace and consequences of continued GHG emission increases globally. Organizations ranging from local, state and national governments to international scientific bodies are calling for an 80% reduction in GHG emissions below 1990 levels by 2050 in developed countries. The State of California has already adopted this goal, and it is now also the goal of the Organization for Economic Cooperation and Development (OECD) nations, including the United States.

We recommend that the City of Tucson itself consider adoption of a similar goal recognizing that there will be significant economic, social and environmental benefits to the community as fossil fuel use is phased out.

Endnotes:

[1] "AZ builders see layoffs outpacing jobs in 2011." http://azstarnet.com/business/local/3959f67f-8746-5bfd-902f-78d61c7ccc90.html

G. Tucson Energy-Demand Response to Higher Energy Prices

This appendix focuses on what effects on the City of Tucson's greenhouse gas emissions might be expected from energy price increases that might occur, if any, from 2011-2020.

It is logical that people will voluntarily reduce their energy consumption, and therefore their GHG emissions, if energy prices (especially carbon-based energy such as fossil fuels or biomass) rise faster than the general inflation rate- in other words, a rise in "real dollars" rather than just inflation-effected dollars. However, the evidence to date suggests that energy demand decreases will be small.

Energy Price Outlooks

Will rising energy prices reduce demand, and GHG emissions?

Most signs point to real dollar energy price increases in the coming decade. The U.S. Department of Energy's Energy Information Administration (EIA), generally considered conservative regarding energy prices, predicted in 2010 that energy prices will rise 2.4% per year for US consumers, slightly above a general inflation rate of 2.2%. The EIA's "Reference case" prediction for the price of gasoline in 2015 was $3.07/gallon, slightly less than an annual 1.5% increase from the national average of $2.86/gallon in November 2010.[1]

However, those price predictions, made during the 2008-10 global recession, are already being increased. The EIA's current 2011 and 2012 projections are for a US average of $3.17 in 2011 and $3.29 in 2012, up 11% and 15% respectively from November 2010. (For more detail, see **Appendix B**)

The BP 2030 Outlook released in January 2011, which does not predict prices, notes that world primary energy demand is expected to continue growing at a 1.9% rate to 2030, putting continued upward pressure on prices, although "energy efficiency…is set to accelerate, facilitating faster income growth over the next 20 years."[2]

The logical response to increasing prices, energy efficiency, means getting the same work done with less energy use. This can facilitate higher energy prices since the consumers with the more efficient devices would therefore be able to pay higher energy costs.

Consumer prices, if exceeding producer costs, will be whatever people are willing to pay, and if a driver can get, for example, 100 miles per gallon equivalent from an electric vehicle instead of 20 from a gasoline vehicle, in theory the driver would be willing to pay five times more for the energy. Users of electric bicycles obtaining ~2,000 MPGe will be wiling to pay even more per unit of energy. But those consumers still stuck at 20 MPG will be economically squeezed as prices rise, and many will have very limited ability to upgrade their efficiency, especially in the short-run.

Likewise, with greater energy efficiency a consumer could choose to use the energy-consuming device more, and not actually decrease their energy demand. A Nissan Leaf owner, for example, who achieves the EPA estimate of 99 MPGe, might drive four times as much as someone with a 25 MPG auto since the energy cost would be the same, and the City would see no energy or CO2 emissions demand reduction as a result

This effect is called the “rebound effect” in sustainable energy circles, and remains a concern from a planning standpoint regarding whether higher energy prices will mean a reduction in auto travel or home sizes, among other energy demands.

The “rebound effect” can also result in economic expansion due to energy efficiencies, which can further increase overall energy demand, reducing the GHG emissions gains made from the efficiency investments.[3]

Additional consumer behavior considerations are (1) the cost of energy relative to the value added, and (2) the marginal costs of energy price increases given sunk capital costs such as automobile or building ownership.

The Relative Cost of Energy

Energy today remains a bargain; it is generally underpriced given how much value it adds to people's lives (i.e. people are willing to pay more for the same services). This is partly due to the reduced real prices of energy since 1980, with only the $140/bbl petroleum in 2008 blip causing prices to not be less in real dollars than the past 30 years. So as wealth increases, new energy demands are brought into people’s lifestyles rather than efficiency investments.

Because energy is underpriced relative to what people would maximally be willing to pay for its service, prices can rise yet energy will still be a great bargain to people, and their conservation efforts it will be limited, if any.

The Marginal Cost of Energy

Some people had energy-efficiency investment reactions to the 2008 gasoline prices, for which there is not a corresponding event in electricity, that indicated they might make behavioral changes to reduce gasoline costs. The US demand for gasoline did drop in 2008, but the effects of conservation due to high prices cannot be separated from reduced consumption because of the recession.

However, the reactions to $4/gallon gasoline were more symbolic/psychological rather than rational since the marginal costs of gasoline in the overall costs of driving are still small even at that price, as shown by people in the EU continuing to increase their driving when prices are twice that much.

For example: if a car gets 25 mpg and gas is $3/gallon, the fuel cost is 12 cents per mile. Assume overall cost of driving is 50 cents per mile, the current Federal/standard mileage reimbursement rate. Fuel cost per mile is therefore 12/50 = 24% of total per mile costs.

If fuel increases to $4/gallon, fuel cost per mile is now 16 cents, but that's still only an 8% increase in costs of driving to 32%. If the car is driven 1000 miles per month, the additional 4 cents is only $40 more per month, which will impact behaviors, especially relatively essential ones, only marginally if at all.

If the vehicle owner spent a net $2000 on a more economical used vehicle that gets 30 MPG (10 cents per mile at $3/gallon), he/she saves only $60 per month, and its takes nearly 3 years to recoup the investment.

This example can be reasonably extrapolated to electricity and natural gas consumer behavior and investment choices.

In summary, there are three important factors that affect whether energy price increases affect demand:

1) Whether people adopt more energy efficient devices;
2) Whether people with more efficient devices consume more energy as a result;
3) Whether economic vitality improves with greater efficiency fostered by the higher prices.

Energy Price Elasticity Measurements

Economists call the effect of different prices on the demand for a good or service its price elasticity. A price elasticity ratio reflects how much consumer demand is likely to change because of a change in price.

This appendix addresses the existing knowledge regarding price elasticity of energy. It is designed to help the City of Tucson address two important aspects of its Climate Action Plan development:

What is likely to happen in Tucson if energy prices rise as predicted by Westmoreland Associates, and how does this affect the many measures proposed and analyzed that aim to reduce energy demand?

What is likely to happen if the City adopts a recommendation to raise energy prices in Tucson in hopes that the higher prices will have the desired carbon-reducing effect on consumer (citizens, visitors and Tucson-based organizations) demand for GHG-based energy.

Price elasticity is expressed as a ratio between the % change in the quantity demanded of the good/service divided by the % change in price as a result. Mathematically: Δ% quantity demanded / Δ% price.

An “inelastic” price – one where the price varies little in response to demand – is the case when the ratio is between -1 and 1. An elastic price range begins with values less than -1 or greater than 1. Elasticity is typically a negative number, since demand usually falls as prices increase.

For example, if prices increase 10% on a good/service with a price elasticity of - 0.20, the demand has dropped by only 2% (i.e. 0.2 elasticity means demand change was 20% of the price change, and the negative number – 0.2 means demand decreased with a price increase). A smaller demand change than price change means demand is "inelastic."

An elasticity of, for example, -1.5 means a 10% price increase results in a 15% drop in demand. This means the good/service is price elastic – i.e. its demand fluctuates by more than the corresponding percentage change in prices.

Elasticity is viewed as short-term and long-term. Short-term refers to the limited ability of people or organizations to change their consumption habits in response to price changes. Long-term allows for investments to be made that can additionally reduce demand.

For energy consumption, examples include more efficient energy-consuming devices such as electric motors, windows, roofs, vehicles, and even size of interior spaces.

As noted by a 2005 study of energy price elasticity for the National Renewable Energy Lab (NREL),

"consumer demand for electricity and natural gas should be relatively unresponsive to price changes in the short-term and more responsive to price changes in the long-term. Demand is generally inelastic in the short-term because a consumer's main options when energy prices change are to vary how he/she uses energy-consuming appliances, or reduce expenditures on other goods."[4]

The NREL study examined various elasticity studies since 1970. Results were mostly consistent that demand is very price inelastic in the short run, and for residential users, inelastic in the long-run as well though one study found a residential elasticity of as much as -2.0.

Energy price elasticity was estimated to be the following for Arizona, the Mountain census region that includes Arizona and the US during the 1990s:[5]

Table 1: Building Energy Price Elasticity Estimates, 1990s

Time period / Energy	Arizona	Mountain Region	US Avg.
Short-run residential electricity:	-0.06	-0.21	-0.24
Long-run residential electricity:	-0.07	-0.27	-0.32
Short-run commercial electricity:	-0.25	-0.26	-0.21
Long-run commercial electricity:	-0.33	-0.9	-0.97
Short-run residential natural gas:	+0.09	-0.18	-0.12
Long-run residential natural gas:	+0.12	-0.44	-0.36

These estimates show that Arizona energy consumers are generally less responsive to energy price changes than consumers elsewhere in the Mountain Region and US, most dramatically different regarding long-run commercial electricity.

However, these elasticities may not reflect actual US or Arizona energy consumer behavior during a period of rapid price increases. The NREL study noted that the 1990s were a period of declining real prices for electricity and relative to the 1980s, lower and stable prices for natural gas.[6]

Price elasticity studies for gasoline found strong inelasticity, mirroring the inelasticity for building energy sources. Elasticity was estimated to average -0.30 from 1975 to 1980, declining to only -0.04 from 2001 to 2006.[7]

However, many Americans responded strongly to the rapid rise in gasoline prices to ~$4/gallon in 2008 with workplace, vehicle ownership or driving habit changes. US gasoline consumption declined 4.3% from 2007 to 2008.[8] Unfortunately, the effects of high gasoline prices are difficult to separate from the effects of the deep recession that began in 2008.

Inability to change and/or disinterest by US consumers in energy efficiency is well documented. The team working on the City of Boulder's Climate Action Plan financing strategy found that energy efficiency was underutilized because it was "boring."[9]

A 2005 report for the Federal Reserve Bank of Chicago by the director of the University of Michigan's Surveys of Consumers was titled, "Energy and the Consumer: What Me Worry?"[10]

The report found that consumer adjustments to reduce vehicle energy consumption "are not easy or pleasant" and that people support regulations "mainly that would regulate other people's behavior, not their own."

Thus, "consumers are generally supportive of regulations that would force vehicle manufacturers to offer more efficient vehicles for sale, even if they would not choose to purchase the resulting higher mileage vehicles themselves." And "consumers react to the real price of energy, its price relative to the prices of other goods and services."

The report was prompted by recent gasoline price increases, and noted that when prices first went above $2 in 2004, consumers' adjustment "was concentrated in reducing smaller purchases and by cutting the rate of their saving to a seventy-year low."

The report's author admitted he did not have conclusive proof of his thesis that, "consumers have misjudged the root causes of the recent rise in energy prices and have therefore misjudged the needed adjustments to their saving and spending plans." But how consumers react to higher energy prices depends on the impact of gas prices on their overall inflation expectations as well as their evaluations of their future financial prospects, and views of vehicle buying conditions.

The report added policy advice that pertains to the City of Tucson's strategy:

"Consumers are more willing to change their behavior when they are optimistic and confident about their economic future, and are more defensive and less open to change when they are pessimistic and uncertain.

Consumers need to be encouraged to adopt more realistic views of the energy market so they can gradually bring their purchases in line with higher future energy prices. The adjustments by consumers need to be gradual and need to begin as soon as possible. If consumers should suddenly change their views and expect permanently higher oil prices, the more rapid adjustment in their spending could have a substantial negative impact on the overall economy."

On the other hand, evidence gathered by the National Energy Board of Canada in 2006 suggested that when people are feeling more optimistic about their economic prospects, "the income effect surpasses the effect of higher (energy) prices…as consumers become wealthier they invest in new energy demand services and so despite the unit efficiency of energy devices improving over time, absolute energy demand is actually increasing."[11]

Research by MIT's Hunt Allcott found that Americans are relatively unlikely to invest in energy efficiency in their vehicle choices, noting that,[12]

"There is a growing body of evidence that consumers choosing between products may underweight, relative to purchase prices, product costs that are less salient or accrue in the future.

Similarly it is often asserted that vehicles' gasoline costs are not salient to automobile purchasers at the time of purchase, and that consumers thus do not fully account for these future costs when choosing vehicles. The purported undervaluation of gasoline costs would help explain the "Energy Paradox": that consumers and firms have been remarkably slow to adopt apparently high-return energy efficient technologies."

Allcott's research of the ten years 1999-2008 concluded that "American auto consumers were willing to pay only sixty-one cents to reduce expected discounted gas expenditures by one dollar."

The University of Michigan's US consumer surveys found similar disinterest in fuel economy as a vehicle purchase motivation. From June 2009 through June 2010, consumers that said that this is a good time to buy a new vehicle to get a "new fuel efficient model" were never more than 4% of the total selected (all choices that applied to their thinking could be selected), whereas over 49% of consumers believed it was a good time to buy overall (as high as 64%).

Such data must be interpreted in light of lower gasoline prices than previous years and little public indication that prices would rise anytime soon. However, the highest percentages of 10-11% selecting "new fuel efficient model" as a good reason to buy a new car only occurred in four months from January 2000 to June, 2010, whereas 0-1% selecting this new car attribute was recorded in 59 months. During the months of highest gasoline price shocks to $4/gallon prior to the 2008 recession, the number indicating this attribute averaged 6.5%.[13]

University of California researchers noted in 2010 that,[14]

"There is reasonable consensus that, when measured over a decade or more to allow consumers time to replace vehicles with more efficient ones, (price elasticity) is around -0.5, that is, if the price of gasoline doubles, its consumption will fall by about half."

However, because of rebound effects of higher vehicle miles driven, the study concluded that a 40% increase in the price of gasoline (e.g. $2.50 to $3.50/gallon) would only reduce fuel consumption by 14.5% in the long-run.[15]

Regarding natural gas, a period of rapidly rising prices occurred from 1999-2006, when consumer prices increased between 73% and 128% according to the US EIA. The increases resulted in past-due accounts and terminations of service by local distributors "becoming more prevalent even during period of mild weather" since energy price increases outpaced growth in household incomes.

Responses included laws/regulations to shield customers from service disruptions, increased low-income assistance programs, and efficiency gains such that during 1990-2006, natural gas usage declined per residential customer by 11%. Efficiency gains in space heating equipment and other natural gas appliances accounted for 60% of the per customer reductions.[16]

Other relevant concepts to potential City of Tucson energy price actions include:

Models of prices for carbon high enough to affect consumer carbon emissions have found that a price of at least $70 per ton is required; $45 per ton is not likely to have the desired carbon emissions (energy conservation) effects.[17]

People are more likely to consider average prices of energy when it is priced with marginally increasing (non-linear) rates such as "conservation" rates, rendering the conservation rates less effective. Highly marginal rates might actually reduce price-related energy conservation behavior because of consumer perception of low average costs.[18]

An EU study of energy use found that despite national programs for energy efficiency and high levels of care about protecting the environment among citizens, energy use rose at the same level as GDP and all types increased in all sectors.[19] EU vehicle use has increased this century corresponding with higher per capita incomes, despite relatively high fuel prices.[20]

What is the Most Likely Climate Emissions Reduction Scenario Corresponding With Higher Energy Prices in Tucson?

Given the historic inelasticity of energy demand to higher prices, and relative inexperience of American consumers with rapidly rising energy prices, it is difficult to extrapolate likely outcomes if energy prices rose rapidly, e.g. 25% in a short time period, whether from global/US markets or from climate change actions by the City of Tucson that would increase energy prices. US consumers have experienced rapid changes in natural gas and vehicle fuel prices with minimal conservation effects, especially in the long-run.

Consumers' expectations of the permanence of the price rise, along with their own outlook on relative inflation (energy price inflation vs. other goods and services), and their outlook on their own financial prospects would appear to be determining factors in the effect.

It is difficult to predict whether people will dramatically change their energy consumption on a permanent basis because of a spike in energy prices, or a steady increase in energy prices in real dollars.

Low energy price elasticity measurements (close to zero) indicate that demand reductions aren't likely for residential consumers, but are more likely for businesses/organizations that are professionally managing their energy expenditures. This difference is shown by the -0.9 long-term commercial price elasticity for energy, and the thousands of examples reported daily regarding business energy reduction goals, programs and investments.

It is more likely that with a price spike, a brief period of consumer/business investments for greater efficiency would be occur, but then replaced by apathy again as the higher energy price level becomes normal.

Much of the response will be dependent on whether people believe the price increase is permanent -which would be contrary to their own life experiences at this point, and how much the City is able to make energy efficiency a culturally preferred behavior and investment through marketing and political/cultural leadership.

Summary

Westmoreland Associates conclusions regarding Tucson-area energy price elasticity are the following:

Residential and commercial short-term response to higher energy prices will likely be a small change in demand.

In the longer-term, commercial response may correspond with energy price increases (i.e. a 10% energy price increase might result in a 10% demand decrease) unless businesses are locked into high-energy consuming.

Energy demand reductions from higher prices or short-term price spikes may be short-lived.

A combination of City of Tucson measures for greater energy efficiency will combine with steadily rising real prices of energy to stimulate efficiency gains and GHG emissions reductions, but neither rising prices nor efficiency measures alone are likely to be effective.

Therefore, the City could expect only a very limited energy conservation reaction to prices even as high as 25% higher, and should not count on projected higher energy prices of the coming decade, to make a significant or even measurable difference in energy demand or GHG emissions.

Endnotes:

[1] US EIA, "Gasoline and Fuel Update," January 2011, at: www.eia.gov/oog/info/gdu/gasdiesel.asp.

[2] BP, "Energy Outlook 2030," January 2011, at: www.bp.com/sectiongenericarticle.do?categoryId=903979&contentId=7066648.

[3] See, for example, Terry Barker and Athanasios Dagoumas, Cambridge Centre for Climate Change Mitigation Research, "The Global Macroeconomic Rebound Effect of Energy Efficiency Policies," May 2009, at: http://www.landecon.cam.ac.uk/research/ eeprg/4cmr/news/pdf/Rebound_Barker & Dagoumas_Rebound_14052009V3.pdf – 1228.9KB. See also, Alok Jha, "Rebound effects of energy efficiency could halve carbon savings, says study," *The Guardian*, May 2009, at: http://www.guardian.co.uk/environment/2009/may/14/rebound-effects-energy-efficiency.

[4] Mark A. Bernstein and James Griffin, Rand Corporation for NREL, "Regional Differences in the Price-Elasticity of Demand for Energy," 2005.

[5] Mark A. Bernstein and James Griffin, Rand Corporation for NREL, "Regional Differences in the Price-Elasticity of Demand for Energy," 2005, pp. 24, 76-79, and 81-89.

[6] Mark A. Bernstein and James Griffin, Rand Corporation for NREL, "Regional Differences in the Price-Elasticity of Demand for Energy," 2005, pp. 17-22.

[7] Carol Dahl, US EIA, "Gasoline Demand Elasticities – 2007 EIA Energy Outlook, Modeling Data Conference," 2007, at: www.eia.doe.gov/oiaf/aeo/conf/pdf/dahl.pdf.

[8] US EIA, "Estimated Consumption of Vehicle Fuels in the United States, by Fuel Type", April 2010, at: http://www.eia.doe.gov/cneaf/alternate/page/atftables/attf_c1.html.

[9] Co-author Christopher Juniper was part of this discussion.

[10] Richard Curtin, Director Surveys of Consumers, University of Michigan, "Energy and the Consumer: What Me Worry?" for Federal Reserve Bank of Chicago, 14 March 2005, at: http://www.sca.isr.umich.edu/documents.php?c=s.

[11] National Energy Board of Canada website, "Consumer Response to Higher Energy Prices – Panel Discussion," summarizing a 2006 event, at: http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/cnslttnrnd1/pnldscssn-eng.html#s2_1.

[12] Hunt Allcott and Nathan Wozny, MIT Department of Economics – Working Papers, "Gasoline Prices, Fuel Economy, and the Energy Paradox," 29 March 2010, at: http://web.mit.edu/allcott/www/papers.html. The findings of the research were contrary to their "null hypothesis" rational model: that consumers are willing to pay one extra dollar in vehicle purchase price to decrease the expected present value of future gasoline costs by one dollar."

[13] University of Michigan Consumer Survey research, at: http://www.sca.isr.umich.edu/data-archive/mine.php?table=26.

[14] Kenneth A. Small and Kurt Van Dender, "If Cars Were More Efficient, Would We Use Less Fuel?", 2007, p. 11., at: www.uctc.net.

[15] Kenneth A. Small and Kurt Van Dender, "If Cars Were More Efficient, Would We Use Less Fuel?", 2007, p. 13., at: www.uctc.net.

[16] US Energy Information Administration, "Impact of Higher Natural Gas Prices on Local Distribution Companies and Residential Customers," 2007, at: www.eia.doe.gov.

[17] Nat Keohane, Director of Economic Policy and Analysis, EDF, "Discussion of Neimeyer, Modeling the Impact of Climate Policy on the Electric Sector," 21 March 2008, at: www.ucei.berkeley.edu/POWER-08/Files/KeohaneSlides.pdf.

[18] Koichiro Ito, University of California, Berkley PhD Candidate, "Do Consumers Respond to Marginal or Average Price? Evidence from Non-linear Electricity Pricing," Univ. of Arizona seminar paper, 20 November 2010, at: econ.**arizona**.edu/docs/Seminar_Papers/Sp%2011_Ito.pdf.

[19] European Commission Joint Research Centre, press release, "Electricity consumption growing in spite of efficiency drive says EU Report," 13 July 2007, at: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1091&format=HTML&aged=0&language=EN&guiLanguage=en.

[20] Lee Schipper, University of California for the World Resources Institute, "Fuel Economy Trends in Industrialized Countries When the Rubber Hits the Road," 2007.

H. Local Economic Impact

Westmoreland Associates predicts that, over their lifetime, all of the 42 carbon reduction measures will have a net positive economic impact on the citizens of Tucson, and therefore the Tucson economy. A net positive impact results when an investment has a positive rate of return. Carbon emission reduction investments typically have positive impacts because of the resulting energy and water savings.

Financial returns are primarily determined by three factors: (1) Initial cost of the investment; (2) The likelihood of the investment achieving the projected savings; and (3) The actual savings to the investor, which is largely determined by the prices of the reduced resource needs such as energy and water. In rare cases the financial returns from indirect benefits are greater than energy and water savings – such as when a sustainable/green building results in greater productivity by building users.[1]

For this analysis, Westmoreland Associates has used the following assumptions for each measure analyzed:

Initial cost of the investment: Costs are considered to be any costs to any citizens of the City of Tucson, whether through City government investments or private investments. In some cases, the measure will likely use investment sources outside the City, especially state or federal government funds. Because the levels of outside funds are not predictable, and the City may experience opportunity costs using outside resources for climate change measures instead of other potential investments, outside sources are considered to be City sources.

Likelihood of achieving projected savings: Westmoreland Associates has not performed a quantitative analysis of the likelihood of a particular measure succeeding. The potential for success of any given measure rests on considerable variables and uncertainties around those variables such that this could easily become a costly and time-consuming exercise unto itself. Therefore, the measures have been carefully crafted to maximize their likelihood of success, partly through maximizing the chances of achieving positive rates of return on the investment.

Investor savings: Westmoreland Associates has consulted with Tucson Electric Power Company and national sources to project energy costs to 2020 that will be saved by each measure. Because water cost savings are inconsequential to the return on investment of the analyzed measures, water costs have not been separately projected or included in the analysis.[2] The energy price assumptions to 2020 can be found in **Appendix B**.

Economic Impact Analysis

All measures are projected to result in cost savings to Tucson citizens. Whether the cost savings are, by themselves, enough to justify the carbon emission savings investment will be ultimately determined through the City's decision-making process. Returns on investment can be viewed by the potential investor as a percentage return figure, or (typically in the case of energy or water savings investments) as the number of years before the investment has paid for itself in savings (after which the annual savings are virtually free until the end of life of the devices involved). Typical government policies consider ten years to be the maximum years over which payback is determined to be acceptable.

Our analysis has developed a net savings estimate for each carbon emissions reduction measure. The net savings is savings achieved after accounting for initial costs and significant ongoing operational expenses. For example, if a new energy-efficient vehicle is purchased, the net savings is the fuel savings achieved over the life of the vehicle less any additional costs of purchase and operational maintenance.

For most measures, net savings will occur (and annually increase based on expected continual increases in energy prices) over a longer time period than this report's analysis of carbon emissions savings to 2020. For example, investments in higher performance new buildings are typically considered over a forty-year lifetime and for automobiles, over a ten-year lifetime. This report has estimated net savings to investors over the expected life of the investment rather than stopping at 2020.

In other words, the price of carbon savings per ton and the net economic impact of savings or costs of the measures reflect the estimated (i.e. typical) lifetime of the investment, whereas the carbon emissions impacts of the investments are calculated only to 2020.

Economic Multipliers

The local economic impact of net savings is projected using a local economic multiplier of 1.5 of the net savings. Economists project local economic multipliers of different types of new income for a region from new jobs and/or businesses. The multiplier reflects the net impact to the economy after the new income has been cycled through the local economy through expenditures.

Multipliers are higher when the new job has a higher compensation level, estimating that each additional dollar of new income has a good chance of being at least partially spent in the local economy. However, economists also recognize that people at different levels of income may have dramatically different spending patterns for new dollars, whether from savings or new income.[3]

If the new income is spent wholly outside the local economy (e.g. investments out of the region or purchases from retailers with no local presence of products with local components), the impact of the income would be zero, and no multipliers would apply.

If the income is spent locally but the recipient spends their new income wholly out of the region, the multiplier would be about 1. Typically, new income is spent by each of its several recipients in such as way that some is retained in the local economy, and the multiplier effect is higher than 1. Depending on the income from the job, the multiplier will be higher since higher income jobs provide greater disposable income. New job multipliers typically are estimated to be between 1.5 and 3.0. For example, a Udall Center economic impact study in 2004 estimated the multiplier from impacts of income generated by immigrants in Arizona at 1.7.[4]

We have not found any estimates of multipliers specific to financial savings by citizens. There is no reason that net financial savings would have a different local economic effect than a new source of income, especially since the primary multiplier determinant is the individual decision on how to spend the savings/income.

If a climate change measure stimulates local purchasing as part of the solution, such as for renewable energy resources, the local economic impact multiplier will be much greater than the 1.5 from cost savings only. As the likelihood of these investments being made locally is difficult to predict, this report has not made economic impact estimates based on projected expenditures.

In summary, the economic impact estimates in this report are very conservative in that a relatively low multiplier is used compared to typical multiplier estimates for new income to a community economy, and zero economic impact is assumed to occur from any investments called for in the various measures.

The economic impacts of some measures will be mixed because the measure reduces energy use, and therefore energy expenditures. For example, a transit-oriented development measure that increases non-auto forms of transportation will likely improve property values and create infrastructure investment savings for the City of Tucson, but might reduce economic activity since less energy is required in people's lives.

Externalities

Economists have increasingly recognized that energy prices do not include important social and environmental costs, including carbon emissions. Such costs not included in prices are called externalities. The market system is set-up to encourage the private sector to externalize as many of its costs as possible in order to be cost competitive, causing externalities to be maximized by businesses wherever possible.

The average of estimates of the externalities of coal-fired electricity, for example, are that negative externalities are likely to be about four times the current US wholesale market price (about 16 cents per kilowatt hour). Suffice to say, any actions that reduce energy use (especially from fossil-fuel-based sources) will have positive economic impacts far beyond its measurable financial impacts by the reduction of externalities.

Though quantifiable estimates of externalities have been made elsewhere, our analysis does not include explicit externality estimates in its economic impacts as this is outside the scope of our analysis.

Endnotes:

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[1] Analysis of high performance green buildings has consistently found that productivity increases are far greater than energy and water savings. See Greg Kats, *Greening Our Built World: Costs, Benefits and Strategies*, Island Press, 2009.

[2] Substantial water use is required for electricity production, and energy use for water delivery such that energy use or water use reductions will have synergistic savings to Tucson's citizens. However, as water costs are embedded in utility rates, they are not separately addressed in this report.

[3] For example, an analysis of the impacts of various taxation or spending strategies by the federal government in late 2010 found that new revenues to high income earners in the form of tax rate cuts would have approximately five times less impact than income to people via extended unemployment benefits (i.e. $40 billion in "high-income tax cuts" would increase national Gross Domestic Product by $10 billion whereas $40 billion of extended unemployment benefits would increase GDP by $52 billion. Source: Chuck Marr, Center on Budget and Policy Priorities, "Letting High Income Tax Cuts Expire Is Proper Response to Nation's Short- and Long-term Challenges," July 2010, at: http://www.cbpp.org/files/7-26-10tax.pdf.

[4] Judith Gans, Udall Center for Studies in Public Policy, University of Arizona, "Immigrants in Arizona: Fiscal and Economic Impacts," 2004, p. 48, at: http://udallcenter.arizona.edu/immigration/publications/impactofimmigrants08.pdf.